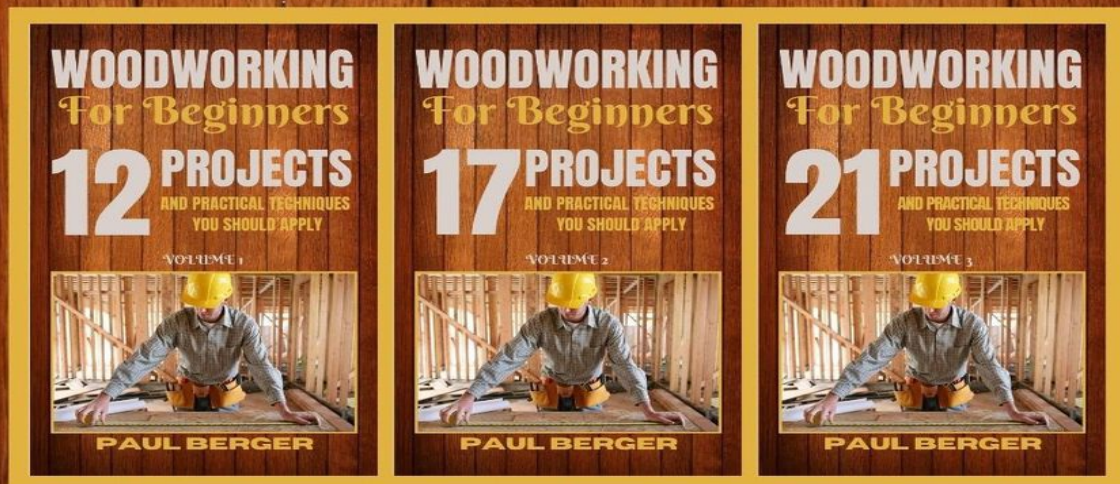
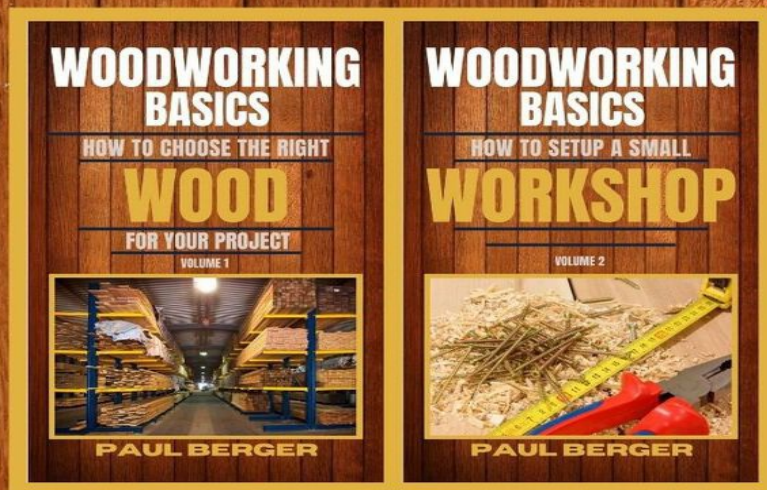


WOODWORKING BIBLE

5 BOOKS IN 1

WOODWORKING BASICS FOR BEGINNERS



PAUL BERGER

WOODWORKING BIBLE
Woodworking basics for beginners
5 BOOKS IN 1

BOOK 1

HOW TO SELECT THE RIGHT WOOD FOR YOUR PROJECT

BOOK 2

HOW TO SETUP A SMALL WORKSHOP

BOOK 3

12 PROJECTS AND PRACTICAL TECHNIQUES YOU SHOULD APPLY

BOOK 4

17 PROJECTS AND PRACTICAL TECHNIQUES YOU SHOULD APPLY

BOOK 5

21 PROJECTS AND PRACTICAL TECHNIQUES YOU SHOULD APPLY

Paul Berger

Copyright

All rights reserved.

No part of this book may be remanufactured in any form or by any electronic, print or mechanical means, including information storage and retrieval systems, without permission in writing from the publisher.

Copyright © 2020 Paul Berger

Disclaimer

The publisher and the author make no guarantees concerning the level of success you may involvement by following the advice and strategies contained in this book, and you accept the risk that outcomes will differ for each individual. The testimonials and examples provided in this book show exceptional outcomes, which may not apply to the regular reader, and are not intended to represent or guarantee that you will achieve the same or similar results.

Contents of Book 1

[Introduction](#)

[Safety tips](#)

[Chapter 1 – Comprehending wood basics](#)

[Chapter 2 – Difference between softwood and hardwood](#)

[Chapter 3 – How to cut lumbers from logs](#)

[Chapter 4 – The properties of wood](#)

[Chapter 5 – How to identify wood](#)

[Chapter 6 – Transportable lumber mills](#)

[Chapter 7 – How to select lumber](#)

[Chapter 8 – How to grade lumber](#)

[Chapter 9 – Understanding hardwood & softwood grades](#)

[Chapter 10 – Understanding lumber effects](#)

[Chapter 11 – How to prepare the lumber](#)

[Chapter 12 – The procedure of veneering](#)

[Chapter 13 – Utilizing plywood](#)

[Chapter 14 – Plywood grading](#)

[Chapter 15 – How to conceal plywood edges](#)

[Chapter 16 – Hardboard versions](#)

[Chapter 17 – How to dry and store wood](#)

[Chapter 18 – How to estimate wood movement](#)

[Chapter 19 – How to store wood](#)

[Chapter 20 – Wood index guide](#)

[Chapter 21 - Wood index](#)

[Bonus Chapter - List of technical terms](#)

Contents of Book 2

[Must have Woodworking Tools](#)

[Chapter 1 – Basic Safety tips](#)

[Chapter 2 – How to prepare your shop against fire](#)

[Chapter 3 – How to prepare for electrical safety](#)

[Chapter 4 – Must have personal safety gear](#)

[Chapter 5 – Must have first aid tools](#)

[Chapter 6 – Planning for basic shop layout](#)

[Chapter 7 – How to plan electrical power layout](#)

[Chapter 8 – How to plan appropriate lighting in your shop](#)
[Chapter 9 – How to prepare the floors, walls and ceilings](#)
[Chapter 10 – How to prepare the heating and ventilation](#)
[Chapter 11 – How to prepare your workbench](#)
[Chapter 12 – How to prepare vises and accessories](#)
[Chapter 13 – How to prepare bench dogs and hold downs](#)
[Chapter 14 – Must have supplementary shop accessories](#)
[Chapter 15 – Air compressor tips](#)
[Chapter 16 – Portable Generator tips](#)
[Chapter 17 – Bench Grinder tips](#)
[Chapter 18 – Dust collection tips](#)
[Chapter 19 – Portable dust collection tips](#)
[Chapter 20 – How to store wood](#)
[Chapter 21 - How to store tools](#)
[Chapter 22 – Work table tips](#)
[Chapter 23 – Sawhorses tips](#)
[Chapter 24 – Work support tips](#)
[Chapter 25 – Extension table tips](#)
[Bonus Chapter - List of technical terms](#)

Contents of Book 3

[Chapter 1 How to make an End Table](#)
[Chapter 2 – How to make a Dining Table](#)
[Chapter 3 – How to make an open pedestal Table](#)
[Chapter 4 – How to build a Card Table](#)
[Chapter 5 How to build a tea cart](#)
[Chapter 6 How to make a breakfast table](#)
[Chapter 7 How to make a Gate-Leg Table](#)
[Chapter 8 How to make a Sofa Table Complement](#)
[Chapter 9 How to make Convertible Tables](#)
[Chapter 10 How to make a Coffee Table with a Glass-top](#)
[Chapter 11 How to make a Trestle Table](#)
[Chapter 12 How to make a modest Coffee Table](#)
[Bonus Chapter How to fit a Chair to a client](#)

Contents of Book 4

[Chapter 1 – Overview of Outdoor Tables](#)
[Chapter 2 Patio Table](#)
[Chapter 3 How to make a Foldable Picnic Table](#)
[Chapter 4 How to make a Joynt Stool](#)
[Chapter 5 Overview of Outdoor Chairs](#)
[Chapter 6 How to build an Adirondack Chair](#)
[Chapter 7 How to make a Curved Chair](#)
[Chapter 8 How to make a lounge chair](#)
[Chapter 9 How to make a Porch Swing](#)
[Chapter 10 How to make a Glider Base](#)
[Chapter 11 How to make a garden Bench](#)
[Chapter 12 How to make a park bench](#)
[Chapter 13 How to make a Tree Bench](#)
[Chapter 14 How to make an 8 sided planter](#)
[Chapter 15 How to make a Serving Trolley](#)
[Chapter 16 How to make a Garden Arbor](#)
[Chapter 17 How to make a Bookcase](#)
[Chapter 18 How to make a Blanket Chest](#)
[Bonus Chapter How to select wood](#)

Contents of Book 5

[Chapter 1 How to build a side chair](#)
[Chapter 2 How to make a rush seat](#)
[Chapter 3 How to make a shaker rocking chair](#)
[Chapter 4 How to make a tape seat](#)
[Chapter 5 How to make a meeting bench](#)
[Chapter 6 How to make a trestle table](#)
[Chapter 7 How to make a drop leaf table](#)
[Chapter 8 How to make a candle stand](#)
[Chapter 9 How to make a step stool](#)
[Chapter 10 How to make a wall clock](#)
[Chapter 11 How to make a pie safe](#)
[Chapter 12 How to make an adjustable shelving](#)
[Chapter 13 How to make tin panel doors](#)
[Chapter 14 How to make a pegboard](#)
[Chapter 15 How to make a drawer](#)

[Chapter 16 How to mount drawers & drawer stops](#)

[Chapter 17 How to design a desk](#)

[Chapter 18 How to build a carcass](#)

[Chapter 19 How to build a frame and panel desk](#)

[Chapter 20 How to design tables](#)

[Chapter 21 How to design legs and rails](#)

[Bonus Chapter How to make tops](#)

[Conclusion](#)

[About the Author](#)

Introduction

Before you get started, you should develop a good safety practice anytime when you are utilizing any type of woodworking machinery or hand tools and ensuring to use common sense when utilizing any common finishes. Also ensure that you are wearing safety glasses at all times, and following hearing protection standard procedure when utilizing any type of woodworking tools. Lastly, ensure that you are reading all following the manufacturer's recommendation for woodworking power tools, and read and follow all safety recommendations.

This book includes 5 manuscripts. In book 1, first we are going to cover some safety tips and comprehending wood basics, such as the difference between softwood and hardwood. Then we are going to look at how to cut lumbers from logs, lumber cutting techniques, how to select the best wood, and what are the advantages of plain-sawn lumber and quarter sawn lumber. Moving on, you will learn the properties of wood, how to work with the grain and how to determine the best direction to plain. After that, you will learn how to identify wood, how to examine a wood sample, how to examine a wood under microscope, how to prepare wood samples for viewing with a lense, how to cut tangential and radial section while you will also learn other wood identification techniques and how to use wood identification keys. Then, we will cover what are transportable lumber mills, what are the procedures from cutting the log into boards, how to select lumber, how to order lumber by the board foot while looking at the Species , Quantity, Size, Grade, Seasoning and Surfacing. After that we will cover how to make and how to use a cutting list for any venture, how to grade lumber, what are the four basic steps lumber graders take to make their assessment, what are the hardwood & softwood grades while you will learn lumber effects and what defect versions are there when it comes to wood. Then, you will learn how to prepare the lumber, how to joint a board, how to plane stock, how to rip cupped stock into narrow boards and how to joint concave and convex surfaces. Moving on, you will comprehend the procedure of veneering, what are the most popular varieties of veener versions and sizes and how to apply the veener. After that, we are going to cover how to use plywood, the procedure of plywood grading, how to conceal plywood edges, how to apply self-adhesive edge banding and how to apply the molding. Then, we are going to cover all

hardboard versions, such as plywood, particleboard, fibreboard and medium density fibreboard. Moving on, you will learn how to dry and store wood, how to use a resistance type moisture meter, how to estimate wood movement and what are the drying times for various woods such as hardwoods and softwoods. Then, we will cover how to store wood, how to build a pipe storage rack, how to make a cantilevered storage rack, how to fasten a lumber and plywood rack to an uncompleted wall, how to make a freestanding plywood rack, how to build a vertical plywood rack, how to wrap dowels with rope, how to store dowels in the ceiling, how to construct a rack with a mobile base, how to make a combination workbench and short cut bin and how to stack stock between wall studs. Lastly, you will have an opportunity to look at 21 species of wood in our directory that was chosen with the needs and interests of the cabinetmaker foremost in mind.

In book 2, we are going to begin covering the must have Woodworking Tools and basic safety tips. Next, you will learn how to prepare your shop against fire, how to prepare for electrical safety, what are the must have personal safety gear and first aid tools that you should consider obtaining. After that, we are going to cover some planning for basic shop layout, where you will learn how to plan the electrical power layout, how to plan appropriate lighting in your shop, how to prepare the floors, walls and ceilings and how to prepare the heating and ventilation systems.

Moving on, you will learn how to prepare your workbench, how to prepare vises and accessories and how to prepare bench dogs and hold downs. Next, we are going to cover the must have supplementary shop accessories and air compressors such as portable generators, bench grinders and dust collectors. After that you will learn how to store wood and how to store your tools. Lastly, we are going to cover the basic requirements of work table, sawhorses, work support and extension tables.

In book 3, we will begin with an End Table, a Dining Table, an Open Pedestal Table, Card Table and a Tea Cart. Next we will build a Breakfast Table, a Gate-Leg Table, a Sofa Table Complement, and you will also learn how to make a Convertible Table. After that, we are going to cover how to make a Coffee Table with a Glass-top, a Trestle Table and a Modest Coffee Table.

In book 4 we will begin with an overview of outdoor tables, and we are going to build a Patio table and a Joynt stool. Next we are going to take a look at an

overview of outdoor chairs, and we will build a Adirondack chair, a curved chair, and a lounge chair. After that, we are going to cover how to make a porch swing, a glider base, a park bench, and a tree bench. Lastly, we are going to make a serving trolley, a garden arbor, a bookcase and a blanket Chest.

In book 5 we will begin learning how to build a side chair, a rush seat, a shaker rocking chair, a tape seat and a meeting bench. Next we are going to look at tables, specifically how to make a trestle table, a drop leaf table, a candle stand and a step stool. After that, you will learn how to make a wall clock, pie safe, adjustable shelving, a panel door and a pegboard. Next, you will learn how to make drawers, desks, frames, legs, rails and tops. If you are ready and excited as me, let's begin.

BOOK 1

HOW TO SELECT
THE RIGHT WOOD FOR YOUR PROJECT

Paul Berger

Safety tips

- Wear appropriate safety gear: safety glasses or a face shield, and hearing protectors or ear plugs.
- If there is no dust collection system, wear a dust mask.
- For exotic woods like ebony, use a respirator; the sawdust may cause an allergic reaction.
- Wear work gloves when handling rough lumber.
- Ensure that workshop lighting and ventilation are adequate and that work surfaces are large and sturdy.
- Read your owner's manual before operating any machine.
- Keep children, onlookers and pets away from the work area.
- Unplug a machine before performing set up or installation operation.
- Keep blades and cutter head knives sharp.
- Turn the machine off if it produces an unfamiliar vibration or noise; have the machine serviced before resuming operations.
- Do not use a machine if any part of it is worn or damaged.
- Roll up long sleeves and eliminate rings and other jewellery that can catch in moving parts.
- Keep your hands well away from a turning blade or cutter head.
- Find a comfortable stance; avoid over-reaching.
- Concentrate on the job; do not rush.
- Never work when you are tired, stressed or have been drinking alcohol or utilizing medications that induce drowsiness.
- Keep your work area clean and tidy; clutter can lead to accidents, and sawdust and wood scraps can be a fire hazard.
- Wear safety goggles, hearing protection, work boots and a hard hat. Ensure your clothes are close-fitting and long hair is tied back.
- Operate a chain saw just outdoors on a dry, clear day.
- Mix fuel and add it to the fuel tank at least 10 feet away from your work area.
- To start up the saw, carry it to the work area and set it on the ground; ensure the chain is not contacting anything.
- Brace the tool with your foot and one hand, and use your other hand to pull the starter cord.
- While operating the saw, hold it firmly with both hands.

How to fell a tree

- To fell a tree to make your own lumber, begin with an undercut one third the way through the trunk on the side facing the direction in which the tree should fall.
- Cut the wedge angling up from the base of the tree.
- Known as the Humbolt undercut, this technique saves lumber from the most valuable part of a tree-the lower part of the trunk-a chunk of which will be lost with the traditional technique of undercutting.
- Then make a back cut a couple of inches above the undercut from the opposite side to fell the tree.
- The back cut should stop an inch or two from the undercut to leave a hinge that will control the direction of the fall and help prevent blade kickback.

Chapter 1 – Comprehending wood basics

As you strive to improve your mastery of the demanding craft of woodworking, much of your attention will be devoted to learning about tools and the techniques for utilizing them.

But in your quest for perfection, do not neglect the most fundamental component of every venture, the wood itself. Seldom perfect and always varying, each piece of wood exhibits its own character, just as certainly as a human being:

Some woods are plain, some colourful; some are stable, some unpredictable; some work simply, some with hardy. Knowledge of these properties will allow you to make the most of your abilities, achieving a wedding of form, substance and technique that can transform even an ordinary venture into a work of art.

You can obtain much factual information about the properties of wood in readily obtainable books and articles. Learning to apply that knowledge is more challenging.

For instance, the knowledge that maple boards may comprise wide variations in color, texture and figure will assume greater meaning as you learn to use these characteristics to best advantage.

Likewise, although Douglas-fir is an eye-catching, simply worked wood, variations in its surface porosity can make it hard to finish well. But when you learn how to seal the wood, you will find numerous uses for Douglas-fir.

Involvement will also tell you that a resilient wood such as pine is more forgiving of less precise joinery, while dense, brittle species such as mahogany demand joints that are cut to close tolerances.

And every beginner rapidly learns that sanding wood across the grain, rather than parallel to it, outcomes in scratches that are accentuated when a finish is applied to the piece.

Recall, too, that how a particular piece of wood behaves in your shop depends in large measure on what happened to it before it reached the lumberyard.

How the wood grew in the tree, the weather the tree endured and how the

wood was cut and dried all affect the final product. The wood of a leaning tree, For instance, will react differently during machining than that sawn from the trunk of an erect tree.

And whether a board is quartersawn or plain-sawn has an impact on its dimensional stability. One way to obtain intimate knowledge of your material is to saw it yourself from a tree utilizing a portable lumber mill.

Selecting and felling a tree, bucking-or crosscutting-it into logs, and milling the planks impart a hands-on understanding that is impossible to acquire any other way.

The work is arduous, and it also takes reviewable time to cut and dry the boards. But the rewards-both in the unique lumber manufactured and the personal satisfaction in producing it are well worth the effort.

Harvested from the trunks and branches of trees, wood is a resilient, dynamic building material. Understanding how trees grow can shed reviewable light on why wood behaves as it does when it is worked or completed.

All trees consist of three major systems: a root network that draws water and minerals from the soil; a crown of leaves, where water and minerals are combined with carbon dioxide in the presence of sunlight to develop food for the tree (photosynthesis); and of most interest to woodworkers-a supporting trunk that transport the water and food.

Viewed in cross section, a tree trunk at first seems to be a fairly homogenous column of wood, marked by a series of concentric bands called growth rings. Nevertheless, a close view discloses a series of distinct layers wrapped around each other, some living, some not.

At the center is the heartwood, the densest-and dead-part of the trunk. Encircling the heartwood is the paler sapwood, which in turn is surrounded by the cambium, the trunk's just actively growing segment.

The cambium's growth accounts for the layers of sapwood that are added each year. On either side of the cambium are layers that transport sap throughout the tree and store surplus food.

As the inner sapwood recedes from the cambium, its pores gradually clog with resins and gums, and become heartwood. As the outer sections become dormant, they form a trunk's outermost layer, the bark.

The differences between sapwood and heartwood are vital to every woodworker. Because it is more porous than heartwood, sapwood absorbs finishes better.

But the denser heartwood is typically more durable and decay-resistant. The carbohydrates present in sapwood cells make the wood vulnerable to fungi and insects. The colors of heartwood are also generally richer and more vibrant than those of sapwood.

Growth rings

- In regions where a tree's growth is interrupted by seasonal change, its wood is characterized by growth rings: concentric bands, typically fractions of an inch wide, perpendicular to the axis of the trunk.
- Trees that grow in temperate areas with a winter season display distinct rings.
- In the tropics, where growth is more or less continuous, a sharply defined ring may just be visible as the outcome of a dry season.
- The rings are intersected by a series of rays: flattened bands of tissue that radiate outward from the pith to the phloem of the tree.
- Growth rings consist of two separate layers.
- The first, called early wood, is laid down at the beginning of the growing season; the second layer, or latewood, is formed toward the end.
- Early wood is more porous than latewood, which accounts for the contrast between the two.
- Taken together, the early wood and latewood of a growth ring in temperate climates represent one year in a tree's life.
- The width of a ring depends on growing conditions and varies from species to species, but changes from year to year reveal a tree's history.
- A wide ring suggests a growing season with ample sun and moisture, while a narrow ring is evidence of disease, unfavourable weather or insect attacks.
- For the woodworker, growth rings are also clues to the strength of the wood: uncharacteristically narrow or wide rings can signal weak timber.

Chapter 2 – Difference between softwood and hardwood

Trees are roughly divided into softwoods and hardwoods, but the terms are inexact: Some hardwoods, such as basswood or aspen, for instance, are softer than North American softwoods like longleaf pine or Douglas-fir.

The type and shape of a tree's leaves are more accurate indicators of a particular wood's identity. Softwoods include evergreen conifers with needle-like leaves, while hardwoods comprise broad-leaved deciduous, or leaf-shedding, trees.

But it is at the microscopic level that the true differences between softwoods and hardwoods can be seen. Softwoods are composed mainly of tracheids, dual-purpose cells which conduct the sap up through the trunk and provide support.

Hardwoods, which are believed to have evolved later, have narrower denser-walled fiber cells for support and large-diameter thin-walled vessels for sap conduction.

These cells determine the texture of a tree's wood. In spring, when there is abundant moisture and rapid growth of early wood, the tracheid cells in softwoods have thin walls and large cavities to conduct the sap.

The outcome is rather porous wood. As latewood develops in the latter part of the growing season, the tracheids begin to form denser walls, creating denser wood. In hardwoods such as oak or ash, most of the vessels develop in the early wood, resulting in uneven grain.

These species are called ring-porous. With diffuse-porous hardwood such as maple, the vessels are distributed more equally in the early wood and latewood.

Some species, such as walnut, exhibit a more gradual transition from early wood to latewood and are termed semi-ring-porous or semi-diffuse-porous. The differences in cell structure between softwoods and hardwoods become apparent when a stain is applied.

In softwoods, the light, porous early wood absorbs stain more readily than the dark, denser latewood—in effect reversing the grain pattern like a photographic negative. Hardwoods, nevertheless, absorb stain more equally, enhancing the grain pattern.

The differences between softwood and hardwood are readily apparent when viewed under a microscope's magnification. The cell structure of softwoods is much straightforward than that of hardwoods.

Almost all softwood cells are long, thin tracheids, which support an unbroken column of sap that can tower more than 200 feet. The tracheids in latewood become denser-walled than those in early wood.

In hardwoods, the sap is conducted through vessels, a series of tube like cells stacked one atop the other. Support for the trunk is provided by fiber cells.

In the ring-porous hardwood, vessels are more prominent in early wood; fibers are the predominant cell type in latewood. In both hardwoods and softwoods, storage cells for carbohydrates and starch make up the remaining non-vascular wood tissue.

For the practicing woodworker, calling a piece of wood by its common name seldom creates confusion. If you ask for a few planks of white oak at a lumber yard, For instance, there is no reason why you should not get what you requested.

But with some species, particularly exotics that must be purchased by mail-order, identities can be less certain. Common names are misleading when trees with different characteristics share the same name, or when the same species has different common names in separate localities.

Suppose you wanted samples of a very rare and expensive species like Brazilian rosewood, a black-streaked, dark brown wood often used in the making of superior-quality guitars.

A supplier could in good conscience send you pieces of kingwood or tulip wood instead, since both belong to the rosewood family and are native to Brazil. In fact, there are several genuine rosewoods, such as East Indian rosewood and cocobolo, that cost much less than the Brazilian diversity and are easier to find.

Nevertheless, they might not fit the bill for a guitar-maker. Other species, such as bocote, bubinga and padauk, are often sold as rosewood substitutes, but do not look at all like Brazilian rosewood.

To avoid confusion, it is helpful to refer to certain woods by their botanical names. Brazilian rosewood is *Dalbergia nigra*, and a guitar-maker who

requests it by that name will not be disappointed.

This scientific naming system was advanced more than 200 years ago by Swedish botanist Carl Linnaeus. In a botanical analysis of Brazilian rosewood, Linnaeus' now universally accepted scheme classifies plants into the various taxonomic groups of phyla, classes, orders, families, genera and species.

Almost all trees belong to the spermatophyta phylum, with hardwoods in the angiospermae sub-phylum and the dicotyledonae class, and softwoods belonging to the gymnospermae subphylum.

Chapter 3 – How to cut lumbers from logs

Between the standing tree and the boards you pick off the rack at the lumberyard stands a complicated procedure that requires numerous people to apply enormous skill at every step.

Undetected defects in the standing tree, damage caused during felling, poor judgment in bucking or inattentive sawing at the mill can sabotage the value of a tree and raise the sawmills and the wood buying consumer's-costs.

Although power saws have substituted muscle-drive pit saws in the forest and at the mill, and cuts are now guided by laser beams and computer technology instead of chalk lines, no replacement has been devised for the practiced eye of an experienced lumberman.

A tree's journey to the lumberyard begins in the woods, when a forester or timber cruiser evaluates the trees for cutting. Not all cut trees will be earmarked for the saw mill; some will be used for pulp or firewood.

These lower-grade trees are deliberately harvested to give the residual stock better access to nutrients and more room to grow, Therefore increasing the timber stand's value.

The very best trees will be reserved for veneer. Since most of the highest-grade lumber will come from the area just under the bark, the forester must be able to detect at a glance clues that betray defects in this area.

Knots, For instance, can be particularly troublesome, depending on where they are located. In the bottom part of the tree, where they are typically indicated by a slight disfiguration of the bark, knots may be so deeply overgrown that they will not affect the value of the outer wood.

But further up, where they are typically indicated by concentric circles or even bumps in the bark, knots pose more serious issues in terms of quality. The ability to differentiate between different versions of fungi is another vital skill in tree evaluation.

All fungi cause some damage, but certain species are rapacious: In beech and hard maple, For instance, as single body of false tinder fungus on the outside of a tree may signal the presence of a 12 to 14 foot long column of decay within.

If the decay were confined to the center of the tree, this would be less of an issue, but numerous fungi infest the most valuable outer wood. Any scarring of the bark is therefore suspicious, since even the tiniest opening makes a tree susceptible to fungal infection.

Bird damage, precisely peck holes made by the yellow-bellied sapsucker also affects a tree's commercial value. Unlike its woodpecker cousins, which eat wood-boring insects that infest dead wood, the yellow-bellied sapsucker feasts on the sap, wood cells, and inner bark of live trees. Persistent feeding outcomes in long streaks of stain that effectively render the wood worthless.

Trees are cut with three passes of a chain saw. The first two cuts eliminate a wedge about one-third of the diameter of the tree, facing the intended direction of fall.

The tree is felled by the third cut, or back cut, made opposite to and a few inches above the wedge. As the tree falls, its direction is controlled by a "hinge" of wood between the wedge and back cut.

Expert fellers review numerous factors before making the cuts-the condition of the felling site, wind direction, the lean of the tree, and the presence of dead branches in adjacent trees, aptly called "widow makers."

Once the limbs have been eliminated, the tree is skidded to a staging area, or landing, where it is bucked into logs. To ensure that the wood is cut to the highest possible grade, the buckler-like the forester or tree cruiser beforehand-has to "read" the tree for signs of defects before setting to work.

Bulges in the bark indicate knots that are close to the surface; large-diameter rotting branches point to decay within the tree trunk. While the optimal length for hardwood logs is 16 feet (8 feet for veneer-quality logs), cutting logs to this length is not always possible.

Sometimes the buckler cuts 8 foot and 12-foot loss to avoid defects that would render-a larger log worthless. In some parts of North America, especially the Pacific Northwest where trees are exclusively large, bucking is done at the felling site before the logs are transported to a central yard.

Steeply sloping terrain may require the logs to be gathered in from the forest floor utilizing a series of cables. One such system is known as high-lead logging. Two main cables, one called a haulback and the other a mainline-are rigged to the top of a tall mast.

Several other cables, called chokers, dangle from the mainline. Trees are felled so they land with their butt sections pointing uphill; crewmen wrap each choker around the butt section of a bucked-up log, signal the head operator and the logs are reeled up the hill to the central pile, typically located next to a lumber road.

When the logs have been detached, the haulback cable is used to pull the mainline and its chokers for another load. No matter how they are moved from the felling site or when they are bucked, logs are loaded onto trucks with a hydraulic grapple hook for the trip to the sawmill.

There are two main versions of sawmills: those that use a band saw and those that use a circular saw. A sawmill is often described according to the type of wood it cuts and the type of saw it employs, such as a softwood band mill or a hardwood circular mill.

Large band mills are often required for the larger-sized logs that are common in the softwood industry in western North America. Circular sawmills, more common in smaller hardwood operations in the East, have a smaller capacity, but are far less expensive than band mills.

The sawing procedure generates a great deal of "waste"-almost one-third of the bulk of each log-but every possible bit of wood is chipped up and used. Some is sold to paper pulp mills or wood-fired utilities.

The volume of wood-burned fuel has increased substantially since the energy crunch of the early 1970s. Today wood supplies about 3 percent of the United States' energy consumption.

Even the bark, which is immediately stripped off the logs, often powers the sawmill's drying kilns. The bark is stripped from the log with large grinding cutter heads or blasted off by high-pressure water jets. The log is then mounted on a log carriage, situated so that the first cuts slice off the widest, clearest, most valuable boards.

In the mill, the sawyer may rotate the log to "read" the log's hidden defects. While in the past this might have been done by hand, it is not uncommon to see today's sawyers work in a glass enclosed booth, forming judgments with the help of advanced electronic tools.

In such a mill, the sawyer uses joysticks like those of a computer game to twirl the log almost a full turn in a matter of seconds, firing a beam of laser

light down its length to visualize the effect of a particular cut before it is made.

In the most efficient mills, sophisticated computers are used to select the best position to obtain the maximum production from each log. First, the four outer slabs of the log are eliminated, giving the sawyer a clean plane from which to make his Then cut-the so-called "opening face"-to give the widest, clearest board obtainable.

Once this face is cut, the log is rotated, and three supplementary boards are cut one from each remaining face. Large mills handling big logs send the remaining square timber called a “cant” to a resawing area for cutting into various sizes of dimension lumber.

Here again, this sawyer must determine the optimum cutting pattern that will yield the most valuable lumber. All the boards are edged, trimmed to length and graded. Smaller mills, and those handling smaller logs, may use a different sawing strategy.

After removing the outer slabs, the boards are cut from the opening face until defects interfere. Then the log is rotated to the next clearest face. As with the first technique, the remaining cant is resawn into lower grade lumber.

Lastly, the boards are sorted, stacked and stickered-separated by thin strips to allow air to circulate between them-for their trip to the drying kiln, where they will remain for up to 50 days.

Lumber cutting techniques

- Converting a log into lumber requires certain compromises.
- Most logs are sawn in one of three basic ways.
- The straightforward technique squares the log and slices it into boards straight through from one side to the other.
- This technique, known as through-and-through sawing, outcomes in stock cut tangentially to the annual growth rings.
- A second technique, plain sawing, is similar, except that the log is rotated as it is cut, and the low-quality pith is set aside for items such as pallets.
- Plain-sawn lumber is also known as flat grained lumber.
- The third technique is called quartersawing or edge-grain sawing, divides the log into four quarters and cuts every board more or less radially.
- Quartersawn boards have their annual growth rings perpendicular to the face.
- This orientation of the growth rings accounts for the dimensional stability of quartersawn boards.
- Wood shrinks and expands roughly twice as much tangentially to the rings as it does radially.
- When quartersawn boards swell or shrink they do so mostly in thickness, which is minimal, whereas a plain-sawn board changes across its width.
- A dining table made from plain-sawn pine boards, For instance, can change as much as 1 inch in width a similar table made from quartersawn boards would just swell or shrink by one-third as much.

How to select the best wood:

- Cutting logs into lumber at a sawmill is a balance between intended use, structural stability and esthetic appearance.
- Plain-sawing produces boards of diminishing width as the log is rotated to make successive cuts.
- The more expensive technique, called quartersawing, limits board width to the radius of the log.
- But it produces more dimensionally stable lumber, making it ideal for drawer sides, tabletops and frame rails.
- Through-and-through sawing yields the maximum number of usable boards from a log; the outer boards are plain-sawn, while the inner boards are quartersawn.
- Quartersawing also offers an esthetic advantage:
- It exposes the medullary rays that radiate from the heart of a log like the spokes of a wheel.
- In most species the rays are just one cell thick, but in a few species, such as oak, the ray cells are denser and appear as vivid streaks scattered along the grain.
- Sycamore, poplar and basswood are also ideal candidates for quartersawing.
- Quartersawn lumber is not always cut perpendicular to the grain, and some through-and-through cut boards close to the center of a log will have quartersawn grain.
- Therefore, no matter how they are essentially cut, boards with growth rings at angles between 45 and 90 degree to the wide surface are classified quartersawn, while boards with rings at 0 to 45 degree angles to the wide surface are termed plain-sawn.
- Boards with growth rings at a 30 to 60 degree angle are also called rift-sawn or bastard-sawn.
- In actual practice, sawyers use a myriad of sawing patterns, depending on the type of machinery being used, the intended use of the lumber, log diameter and the type of tree.
- For instance, in virtually all trees the pith or central core of the heartwood is less desirable than and not as robust as the rest of the heartwood.
- Plain-sawing "boxes out the heart" by cutting around it to

eliminate it.

Advantages of plain-sawn lumber

- Inexpensive and easier to obtain.
- Shrinks and swells less in thickness.
- Typically comes in greater diversity of widths.
- Less susceptible to collapse during drying; easier to kiln dry.
- Figure patterns resulting from the difference between earlywood and latewood in the growth rings are more conspicuous.
- Has more interesting figure.
- Round or oval knots that may occur have less effect on structural integrity.
- Pockets of pitch extend through fewer boards.
- Not as susceptible to splitting when nails or screws driven through face.

Advantages of quarter sawn lumber

- More dimensionally stable.
- Shrinks and swells less across the board.
- Twists and cups less.
- Splits and checks less in seasoning and in use.
- Raised grain caused by the swelling of the earlywood in growth rings not as pronounced.
- Figure due to pronounced rays more conspicuous.
- Holds finishes better in some species.
- Sapwood inboards seems at the edges and is simply cut off.
- Wears more equally.

Chapter 4 – The properties of wood

An experienced woodworker pays close attention to the selection of wood for a venture. Every species has unique qualities that can make it ideal for one application but unsuitable for another.

Among the key properties that differentiate woods are color, grain, texture, figure, weight and odor. Numerous species are prized for their distinctive colors.

Padauk is a fiery orangered; black walnut often exhibits deep purples and chocolate tones. Color in wood is the outcome of extractives such as tannins, gums and resins in the wood.

When cut lumber is exposed to air, these substances gradually oxidize, deepening the wood's color. In some cases, nevertheless, the color may fade. Grain and texture are two distinct properties that are often confused.

Grain describes the direction and regularity of the wood fibers relative to the axis of the tree trunk. The grain displayed by a piece of lumber depends on the growth pattern of the tree from which it was cut.

A wood's texture depends on the size and distribution of its cells. Ring-porous hardwoods with large vessels have a coarse texture, while diffuse-porous hardwoods with fine vessels have a finer texture.

In some softwoods, abrupt transitions from earlywood to latewood develop an uneven texture. Where there is little or no transition, as in white pine, the wood has an even texture.

An vital quality in veneers-is the pattern displayed on the surface of a board. This is the expression of a board's character the sum of its grain, contrast between earlywood and latewood, eccentricity of growth rings, mineral streaks, disease and the technique used to saw the log.

For instance, plain-sawn white birch discloses a so called landscape figure. Interlocked grain produces the ribbon figure common in African mahogany. Wavy grain in maples outcomes in a fiddle back figure, so named because of its use in the backs of violins.

And irregular growths on the outer surfaces of trees, such as elm, yield an intricate burl figure. The weight of different wood species is expressed as specific gravity, or its density compared to an equal volume of water.

The specific gravity of an oven dried sample of American elm, For instance, is 0.50, making it half as heavy as a tropical hardwood like ekki, which has the same specific gravity as water 1.00.

Lignum vitae, the heaviest wood, has a specific gravity of 1.23. The higher a

wood's specific gravity, the less porous it is and the more impervious it will be to a finish.

A wood's odor typically caused by oils in the heartwood-may also determine its use. An aromatic species like cedar, For instance, is often used for clothes chests and cigar boxes.

How to work with the grain

- Numerous woodworking tasks, especially planing, require working in the direction of the grain.
- You can typically tell grain orientation by running your hand along aboard face:
- The surface will feel smoother when your hand is moving with the grain and rougher when running against it.
- Another technique is to slide a smoothing plane lightly along the face in one direction, then repeat in the opposite direction.
- The blade will chatter or catch on the wood fibers when it is cutting against the grain.

How to determine the best direction to plain

- To prevent a plane blade from catching the grain and tearing or chipping the wood fibers, always cut in the uphill grain direction.
- This will develop clean shavings and a smooth surface.
- Be especially cautious to spot grain that changes direction within a single board.

Chapter 5 – How to identify wood

Whether you are restoring a piece of furniture made from an unfamiliar wood or debating the authenticity of a particular board with a local lumberyard, a knack for identifying a piece of lumber is a useful skill.

Of course, an entire branch of knowledge is devoted to wood science and technology. Books have been written about the subject, careers have been founded upon it, and universities offer courses and degrees devoted to it.

Scientists identify wood by first slicing off a thin sliver of a sample, then mounting it on a slide and examining it under a microscope. The practicing woodworker, Nevertheless, who is more interested insawing than in science, can successfully identify most woods by methodically searching for a few straightforward clues with the help of inexpensive tools.

Your investigation should begin with the simply observable properties of the sample. Examine and feel the surface; determine whether it is oily or dry, dull or lustrous.

Confirm its hardness by trying to dent the surface with a fingernail. You may be able to tell with the naked eye whether a hardwood is ring or diffuse porous.

Whether the texture of the wood is coarse or smooth. If the sample has been recently cut, it may have a recognizable odor. If it has been sufficiently dried, you may be able to calculate its specific gravity.

Although these observations can help narrow down the choices, you will still have to view a wood sample under magnification in order to hazard and educated guess as to its species.

The three ways that a sample can be studied: transversely, radially or tangentially. Each technique exposes a different view of a sample's anatomical structure.

The straightforward view is the transverse since it involves looking at the end grain of the sample. Nevertheless, to avoid a blurred view of crushed fibers, you must first shave the surface with a razor blade or a well-sharpened knife.

To get a tangential view of a sample, you will need to make a clean cut along the growth rings of the wood. Making a second cut at right angles to the first

exposes a radial view.

Once you have observed and recorded the sample's properties and microscopic particulars, you can compare the outcomes with a printed key of wood species to identify the wood.

How to examine a wood sample

- The 10x magnification provided by a magnifier or hand lens allows you to examine three views of wood's structure.
- The transverse section lies at right angles to the grain and is visible in the end grain of stock.
- The tangential and radial sections are at 90 degree to the transverse section.
- The tangential section follows a straight line that is tangent to the growth rings.
- This section is the surface you see on the face of plain-sawn lumber.
- A radial section is exposed by cutting a straight line from the bark through the pith, exposing grain lines that appear as vertical strips.

How to examine a wood under microscope

- At 100x magnification, a microscope uncovers more particulars of the cellular structure of wood than can be seen through a hand magnifier.
- The transverse section will display the size of the tracheid cells and the transition in their density from earlywood to latewood.
- Also evident is a longitudinal resin canal.
- The tangential section will also display the number and thickness of the rays in the wood.

How to prepare wood samples for viewing with a lense

- Slice off a sliver of wood from the end grain of your sample utilizing a sharp knife or razor blade.
- The surface should be smooth and even.
- If the wood is particularly dense and hard to cut, first soak the end grain for a short time in hot water.

How to cut tangential and radial section

- For a tangential section, mark a cutting line tangent to the growth rings on the edge of the sample.
- Cut along the line with a band saw, making sure your hands are not in line with the blade of the tool.
- For a radial section, make an end-to-end cut through the sample at the high point of the growth rings with the piece face down on the band saw table.
- To clean up the cuts for viewing, lightly smooth the surfaces with a hand plane.
- Avoid utilizing sandpaper, which will crush the fibers.

Other wood identification techniques

- Although identifying wood requires cautious observation of the appropriate features of a sample, practice makes the job easier.
- First measure the width of the growth rings, and note the color and luster of the wood.
- Recall that wood exposed to sunlight and air changes color, so the hue of a freshly cut sample may be different after it has dried, Luster is not a common feature of numerous woods, but it can help differentiate between species that are otherwise alike in color, texture and weight.
- Although odor, like luster, is distinctive for just a few woods, it can be a useful key to identification, particularly among softwoods.
- Odor is most pronounced in freshly cut lumber, and can be revived

by moistening a dry wood sample.

- Checking a sample for hardness by running a fingernail along the grain and noting the degree of indentation can help differentiate similar species such as butternut and black walnut.
- The standard tool for macroscopic viewing of wood is a 10x hand lens.
- Select one with built-in illumination for sharp resolution.
- Examine samples in good light, holding the lens close to one eye and moving the surface to be studied into focus.
- Note the distribution and shape of features such as vessels, tracheids, resin canals, earlywood, latewood, pores and medullary rays.
- The relative diameter of vessels in hardwood or tracheids in softwood is vital in determining the texture of the wood; the larger these cells, the coarser the wood.
- The distribution of pores within the growth rings will also tell you whether a hardwood is ring-, diffuse-, semi-ring- or semi-diffuse-porous.
- When viewing end grain, select an area of regular growth rate, avoiding defects like cross grain and knots.
- With softwoods, look for resin canals; they are just present in pine, spruce, larch and Douglas-fir.
- If you are looking for rays-an vital feature of hardwoods-they are best seen on a transverse or tangential surface.

How to use wood identification keys

- Correctly identifying an unfamiliar wood sample out of thousands of possibilities requires close observation, and a thorough knowledge of wood and its properties.
- But as a practical matter, the possible choices are typically limited to several familiar species, and a commercially obtainable set of labeled wood samples may include a piece that matches the wood you are attempting to identify.
- Most often, nevertheless, you will need to record the features of a sample, and then use a wood identification key from a book to make sense of your outcomes.
- An identification key is essentially a master list of woods and their properties that serves as a cross-reference to link the features of a particular sample to a species name.
- Some keys require that you compare their entries against features that are visible to the naked eye or with a 10x magnifier, while others demand that you note microscopic particulars.
- Still other keys are based on the user having wide-ranging sensory information about the wood, including its color odor and texture, and the bark and leaf shape of the tree from which it came.
- Utilizing a key is like climbing the branches of a tree.
- You are asked to answer a series of paired statements, choosing the one that best describes the wood in question and proceeding to the Then pair indicated.
- At each statement, the user forks onto a different branch until reaching a leaf that identifies the sample.
- The first statement may involve the texture of the wood.
- If the wood is porous, For instance, you are sent to one set of statements; if it is non-porous, you jump to a different set of statements.
- You continue this way, flipping from page to page in a book, as each answer gradually decreases the choices.
- Lastly, the search is narrowed to a single species.
- Avoid keys that try to cover every wood species in the world; they will prove too general.
- Select one that describes trees in a specific region, such as North

American softwoods or tropical hardwoods.

- Several classic keys can be found in woodworking books; confirm your local library or bookstore. Some public agencies also offer wood identification services.
- How to use a wood identification key
- Here is an example of how a typical wood identification key works.
- In this case, we are starting with a plain-sawn board of an unknown wood.
- The first step is aimed at narrowing the investigation to either the hardwood or the softwood portion of the key.
- You examine your sample with a hand lens and observe that it has vessels and is porous; according to your key, it is a hardwood.
- Then, you must determine whether the wood is ring- or diffuse-porous:
- You notice that its earlywood is not sharply defined; you are told that it is diffuse-porous.
- Then features to examine are the rays.
- Seen in the tangential view of your sample, the rays are rather narrow and uniform in width.
- This observation leads to another concerning the size of the pores in the growth rings.
- Since the pores in the earlywood of your sample are larger than those in the latewood, this indicates that you have a semi-diffuse-porous wood.
- Then, you examine the distribution of the pores in the growth ring.
- If they were unequally distributed, the key would identify your sample as tanoak.
- Instead, the pores in your sample are equally distributed.
- You must then evaluate the storage cells in the latewood.
- Seeing that they are present in a fine, unbroken line, you are directed to determine the color of the heartwood.
- If it were chestnut-brown or chocolate, you would have a piece of black walnut or butternut.
- But since the heartwood is brown to yellow-brown, you have either water hickory or persimmon.
- Since the rays of your sample are stacked vertically, creating

ripple marks, the key leads you to the end of your quest: the sample is persimmon.

Chapter 6 – Transportable lumber mills

The desire to gain a deeper understanding of wood ultimately leads some woodworkers out of the shop and lumberyard, into the woods, and back to the tree itself.

By sawing your own Lumber from logs, you can develop boards that exactly meet a venture's specifications and gain valuable insight into wood as a living material.

Each step yields a thrill of discovery as you watch patterns of grain and figure emerge from the log. A number of lumber mills on the market allow you to cut through-and through cut, plain-sawn or quartersawn boards.

These tools include large stationary production mills capable of cutting logs more than 20 feet in length, portable models with tough band saw blades, and still smaller units that use chain saws.

The procedures that follow teach you how to cut logs into lumber with a chain saw that is guided by a jig that attaches to it. Besides the cutting jig and a heavy duty saw, this straightforward technique requires nothing more than a straight board, a hammer and a few nails.

Most chain saws are intended to crosscut trees-that is, buck the logs into shorter lengths after the trees are felled and delimbed. Cutting logs into lumber is a ripping operation in which the sawing is done along the length of the log.

Ripping with a chain saw requires at least three times as much power as crosscutting, and the saw must run at full throttle throughout most of the cut. Because much portable lumber milling involves hardwood logs, it is best to use a direct drive chain saw rated at a speed of at least 3000 feet per minute, with a ripping chain installed.

To minimize strain on the saw, try to select logs that are rather free of defects such as twist and taper, with few knots and burls. Felling trees and cutting logs with a chain saw is dangerous work requiring safe working habits.

Pay attention to your task at all times and keep cutting edges sharp, clean and well maintained. Since prolonged work with chain saws can damage the ears, wear hearing protection, such as earplugs or ear muffs.

Proper dress for chain saw work also includes a full face shield and steel toed boots; do not wear loose clothing. You can also don special chain saw gloves to protect your hands and a pair of safety chaps made from a tough, synthetic fiber to protect your legs should the saw accidentally slip or jump back.

How to cut the log into boards:

1 - Squaring the log

- To mark out the cant, the squared off part of the log-and maximize the number of boards the log will yield, scribe a square on both ends of the log.
- Start at the end with the smallest diameter.
- Place the inside angle of a carpenter's square just inside the bark, and mark two outside edges of the square with a pencil.
- Utilizing the scribed lines as a guide, complete the square.
- Measure the sides of the square and transfer them to the other end of the log, making sure that the pith is centered in the square.

2 - Choosing the cutting pattern

- Before cutting the log, select between through and through cut and quartersawing and mark out the appropriate cutting pattern on the ends of the log.
- For through-and-through cut lumber, scribe a series of lines within the square so that the board faces are roughly tangent to the growth rings.
- Space the lines according to the board thickness want.
- For quartersawn lumber, divide the square into three segments.
- Mark out the middle segment as for through-and-through cut lumber, and then scribe lines in the two outside segments that are perpendicular to those in the middle.
- The growth rings will be more or less perpendicular to the faces of these boards.

3 - Cutting the cant

- Set the log on spacers, with one side of the marked square vertical.

- Cut a 2 by 4 guide longer than the log, and then position it on top of the log so that it extends beyond each end.
- Align the outside edge of the guide with the side of the square and nail it in place.
- Use wood shims to level the guide.
- Place the lumber-cutting jig on the guide and adjust its fence so that it runs smoothly along the guide.
- Attach the chain saw to the jig following the manufacturer's instructions.
- To make the cut, position the jig on the guide at the smallest end of the log.
- Then, with the saw blade clear of the log, start up the saw and tip it forward so that the blade bites into the log.
- Carefully step backwards and draw the jig along the guide, cutting through the log to the other end.
- To cut the other sides, eliminate the guide and rotate the log.
- Repeat the procedure to align the guide with the square and make the cut.
- Continue until all the sides are cut.
- To cut the resulting cant into boards, use the chain saw and the jig to cut along the lines you marked in step 2.
- If you have a band saw, you can cut the log into a manageable 6 by 6 cant with the chain saw, and then use the band saw to cut the cant into boards.
- With its narrower kerf, a band saw blade produces less waste than a chain saw blade.

How to simplify squaring the ends of a log before cutting it into lumber with the crosscutting jig

- The jig, which can be built to fit a diversity of log sizes, consists of a guide and an inverted L-shaped frame with two triangular support brackets.
- To make the jig, cut two pieces of $\frac{3}{4}$ inch plywood for the frame.
- The lengths of the pieces should exceed the diameter of the largest log you expect to handle.
- The width of the top piece should equal the desired width of cut.

- Screw the two pieces together along with the triangular brackets.
- Screw a 2 by 4 guide that is at least 8 inches longer than the diameter of the log to the top piece, aligning its edge with that of the top piece.
- To use the jig, set the log on spacers and position the jig atop the log.
- Nail the side piece of the frame to the end of the log, making sure that the guide is level and square to the log's axis.
- Set up the chain saw and the lumber-cutting jig on the guide as you would to cut a log into a cant.
- Then start the saw and tip it forward so that the blade bites into the log.
- Draw the jig along the guide until you cut through the log.
- At the end of the cut, the crosscutting jig and the cut off piece will topple toward you.
- Keep the blade from binding in the kerf and stand clear of the jig at the end of the cut.

Chapter 7 – How to select lumber

Some craftsmen buy their wood venture by venture. They design and lay out a piece of furniture, calculate the amount and type of wood required, then embark on a quest for exactly what they need.

Other woodworkers stockpile beautiful or interesting pieces of wood even before they have a specific venture in mind.

Picking through the piles at the local wood dealership, surveying felled logs at a building site or scavenging bucked logs left over from roadside tree work, these craftsmen accumulate promising wood in the drying shed a supply that serves as an inspiration for future work.

Whatever your approach, there are several sources to cover in your search for raw supplies. The most obvious is the local lumberyard. Some yards stock specialty items, depending on demand in the areas they service; lumberyards along the coast, for instance, might carry mahogany and teak for boat building and repair.

But because most yards mostly supply the building trades, your solid-wood choices will perhaps be limited to structural softwood lumber and perhaps an occasional piece of oak.

For a wider choice of hardwoods, and for wood carving and turning blanks, you will have to range farther afield. Look for dealerships that specialize in fine hardwoods, or scan the advertisements in woodworking magazines for mail-order woodworking-supply companies.

You will pay top dollar for hardwoods bought from a retail source, but in return you will generally receive material that has been graded for quality utilizing the standards established by the National Hardwood Lumber Association.

In addition, some care has perhaps been taken to control the moisture content of the stock during its stay in the yard. You can also ask the retailer to furnish stock that is surfaced to a uniform thickness—a necessity for woodworkers who do not have access to a power planer.

There are other, less costly ways to obtain wood. If you live near a small sawmill, you may find good quality lumber at a very low price. Nevertheless, the wood will perhaps be green, rough and ungraded—and it must be stickered,

seasoned and surfaced before it can be used for furniture.

Larger sawmills prefer to deal with large volumes of wood and maybe reluctant to fill small orders. One answer is to pool your material needs with those of other woodworkers.

Some sawmills will sell you their "planer outs"-small pieces of varying widths and thicknesses that can be bought at bargain prices. It may also be economical for you to buy wood that has been recycled after numerous years of use in bams, factories, wharves and other structures.

You may also find an opportunity to do your own recycling. Reutilizing old wood makes sense environmentally, and it is rapidly becoming the just legal way of obtaining some species.

In addition, recycled boards that were cut from straight-grained old-growth timber may be superior to fresh lumber cut from smaller trees. There are drawbacks to recycling wood, Nevertheless.

Wear, rot and insects may add up to a waste factor of 50 percent or more. And you should expect to extract numerous nails, bolts and staples-and still ruin saw blades in encounters with hidden metal.

How to order lumber

- When it is time to order lumber for a venture, it pays to do your homework before you go to the lumberyard.
- By becoming an informed and well-organized consumer, you increase your odds of coming away with your needs met and your wallet intact.
- You will also avoid having to make extra trips to your supplier.

Species

- Ask for a specific wood species, not merely a broad family name.
- For instance, order "white oak," not just "oak."
- Every species has unique properties; select one with the characteristics that suit the needs of your venture.
- It can be helpful to learn the basics of wood identification, since at some lumberyards several similar versions of woods may be lumped together under the same name.

Quantity

- Lumber may be ordered either by the linear foot or the board foot.
- Be sure your supplier knows which measure you are using, because they are very different.
- Board-foot calculations, which essentially describe a volume of wood, are explained shortly.
- As a general rule, you can order stock of like dimension by the linear foot 25 linear feet of 1 by 4 lumber, For instance.
- The main limitation of this technique, Nevertheless, is that it just works with lumber of uniform width and thickness.
- Once you mix dimensions-as you perhaps will end up doing when ordering hard wood a board foot measurement becomes necessary to describe your needs.
- How you order your wood can also depend on whether you need softwood or hardwood with softwoods you can typically specify any board width or length, while hardwood boards are generally obtainable in random widths and lengths, depending on the grade

you order.

Size

- Wood is sold in nominal rather than real sizes, so recall to make allowances for the difference when ordering surfaced lumber.
- A 1 by 6 piece of pine, For instance, is essentially $\frac{3}{4}$ inch thick and 5 $\frac{1}{2}$ inches wide when dried and surfaced.
- With rough, or unsurfaced green lumber, the nominal and real sizes are the same.
- The thickness of hardwood boards is commonly expressed as a non-decreased fraction in quarters of an inch.
- A 1 inch thick oak board, For instance, is termed $\frac{4}{4}$ lumber a 1 $\frac{1}{2}$ inch thick plank is $\frac{6}{4}$ and so on.

Grade

- When ordering a particular grade of wood, use standard terminology.
- The main differences between higher and lower hardwood grades lie in appearance rather than strength.
- In general, reserve higher-grade wood for the visible parts of your ventures.

Seasoning

- Lumber is sold either kiln-dried (KD) or air-dried (AD).
- The practical difference between the two is that KD wood has a lower moisture content about 8 percent, while air-dried, high-density hardwoods generally have a moisture content range of 20 to 25 percent.
- Softwoods and lower-density hardwoods are air-dried to 15 to 20 percent moisture content.
- KD lumber therefore preferable for making indoor furniture, because the wood is unlikely to dry out any further; as well, the kiln's heat allows the wood's cells to reposition, reducing the likelihood of warping and checking.

- This does not mean you need to restrict yourself to buying just KD lumber, nevertheless; in fact, numerous carvers prefer moister wood, making AD wood a better choice for them.
- You can bring air-dried wood to the appropriate moisture level for cabinetmaking.

Surfacing

- Also known as dressing, surfacing refers to how lumber has been prepared at the mill before it is sent to the lumberyard.
- Lumber that is surfaced is typically surfaced on both sides: S2S lumber has been planed smooth on both faces, while S4S wood has had both faces planed and both edges jointed.
- Rough, or unsurfaced, lumber is less expensive than either S2S or S4S wood, and if you own a planer and a jointer, you can save money by surfacing rough lumber in your shop.
- A sample order for wood at a lumberyard might be as follows: 100 bd. ft. 8/4 FAS red oak, S2S.
- This would amount to 100 board feet of nominally 2 inch thick FAS (Firsts and Seconds) grade red oak with both faces planed smooth.
- Once you receive your lumber, confirm it carefully to ensure you are getting what you want.
- If the order does not meet your specifications, do not feel obliged to buy it.

How to order lumber by the board foot

- Because the board foot is a unit of measurement that offers a standard way of totalling the volume of stock irrespective of dimensions, it is commonly used when dealing with lumber.
- The standard board foot is equivalent to a piece that is 1 inch thick, 12 inches wide and 12 inches long.
- To calculate the number of board feet in a particular piece of wood, multiply it's three dimensions together.
- Then divide the outcome by 144 if the dimensions are all in inches, or by 12 if one dimension is expressed in feet.

- For the standard board, the formula is: $1" \times 12" \times 12" \div 144 = 1$ (or $1" \times 12" \times 1' \div 12 = 1$).
- So if you had an 8 foot long 1 by 3, you would calculate the board feet as follows: $1 \times 3 \times 8 \div 12 = 2$ (or 2 board feet).
- Recall that board feet are calculated on the basis of nominal rather than actual sizes.

How to make and utilizing a cutting list

- A cutting list records the completed sizes of the lumber required for a particular venture.
- It may be included with the plans you purchase; otherwise, you will have to fashion your own based on a drawing of the design.
- Tally up the number of board feet for each piece utilizing the above formula; tack on an extra 30 to 40 percent to account for defects in the wood and waste.
- For instance if totals roughly 16 board feet, you should order at least 20 or 25 board feet of 4/4 lumber in addition to the necessary quantity of plywood sheeting.
- The cutting list should include the name of the part, the quantity, the dimensions of the pieces and the kind of wood suitable for the venture.
- For convenience, assign a letter to each piece.

Chapter 8 – How to grade lumber

Lumber grading is a way of evaluating the surface quality of a board according to certain standards, taking into account factors such as the number, size and degree of defects in the wood.

The objective is to ensure that woodworkers get what they pay for; a board of a certain grade of wood bought in Maine will closely resemble a similar-grade board purchased in New Mexico.

At first glance, the rules of grading may seem arbitrary. For starters, the standards are different for softwoods and hardwoods, the outcome of the end use of each type of wood. Softwoods are mostly used in building, so a grader may assume that a softwood board will be used as is, with no further surfacing.

Hardwood boards, on the other hand, are almost always planed, crosscut and ripped into smaller pieces to fit a particular piece of furniture. Added to that is the fact that, while there is one standard for hardwoods, softwoods are further divided into separate groups and graded according to rules established by different organizations.

Taking the time to become familiar with hardwood and softwood grading will pay dividends. A sound understanding of the grading system enables you to select the most appropriate board for the job at hand; it can also save you money.

There is no need, for instance, to order long planks of top grade FAS (or Firsts and Seconds) lumber if most of the pieces of the cabinet you intend to build are just three or four feet long. You would perhaps be better off buying No. 1 Common, which is cheaper, and will be adequate once you have cut out the defects.

Lumber producers and vendors have long found it advantageous to study wood species and set rules for grading to guarantee a uniform product. The best way to become familiar with grades is to visit a lumberyard and examine stock first hand.

Get to know how a hardwood grade like FAS differs from No. 1 Common. And when you select lumber, try to picture how each part can be cut out of a board with the least waste.

Evaluation of a typical board

- Equipped with lumber rule, pen and log book, a occupational lumber grader can evaluate a hardwood board in roughly 15 seconds.
- Although the system is scientific, it is not fool proof .
- Grading is all done by eye-the eye of a human grader.
- Still, rigid quality control ensures that just a very small percentage of boards are not graded correctly.

Four basic steps lumber graders take to make their assessment

1 - Determine the species and multiply the length by the width of the board to find the surface measure (SM) in square feet in the board above, 12 inches (1 foot) x 12 feet = 12 SM.

2 - Select the poorest face from which to grade and visualize the number of imaginary defect free cuts that can be made.

3 - Determine the number of portions of cutting units clear lumber 1" wide by 1 long that can be made from the 4 cuts; in this case, $108 \frac{1}{4}$. If the board were perfect, it would yield 144 cutting units.

4 - Consult a chart that lists the qualities of different grades and factor in the number of cutting units and the number of allowable cuts: A No. 1 Common board requires that two thirds of the total cutting units are clear. Given the size of this particular board, up to 4 cuts would be allowed.

Chapter 9 – Understanding hardwood & softwood grades

Hardwood grades

- A hundred years ago, hardwood grading varied from mill to mill, but with the formation of the National Hardwood Lumber Association (NHLA) in 1898, grading became standardized.
- At first, the rules were based strictly on the number and size of defects; in 1932 they were broadened to reflect the proportion of a board that can be cut into smaller pieces, called cuttings.
- These pieces must be clear on one side and sound on the other.
- Their size also determines the grade.
- Today's hardwood grading standards assume that boards are invariably cut into smaller pieces to make furniture; Therefore, grade is based on a board's poorest face, except in the case of "Select", which takes the board's best face into account.
- Select is one of seven standard hardwood grades. The top grade is FAS aka Firsts and Seconds, followed by Select, No. 1 Common, No. 2A and 2B Common, and No. 3A Common and No. 3B Common.
- No. 2A and No. 2B Common are often lumped together as No. 2 Common; likewise, numerous lumberyards sell No. 3A and No. 3B Common together as No. 3 Common.
- The better the grade, the higher the percentage of clear cuttings: 83 1/3 percent of Select boards must be clear face cuttings; just 50 percent of a No. 2 Common board need be defect free.
- But grading is a more subtle art than these calculations indicate.
- Two boards that are the same size with the same number of defects can end up in different grades:
- The position of the defects may prevent one board from having large enough clear cuttings to make the higher grade of the other board.
- Although paying more for better grade stock means that you will end up with wood having fewer defects, this may not always be the economical thing to do.
- If your venture is rather modest, hand-pick the lumber yourself from a diversity of grades, depending on the function of each

board in the piece.

- Where just one defect free face is called for, the select grade is a good choice.
- Or, for the pieces of your furniture venture that are rather small, For instance, you may be able to get by with No. 1 Common grade boards. No. 2A Common boards are suitable for the parts of ventures in which appearance is not of paramount importance, such as hidden furniture frames.
- If you do buy lower-grade lumber, nevertheless, plan on more waste where you are calculating the number of board feet to order.
- Of course, beauty is in the eye of the beholder.
- Some cabinetmakers feel that defects such as knots add character to a piece of furniture.
- And if most of the parts will end up being small, lower grade wood is not just economical; it may also be more suitable for the task at hand-by yielding more eye-catchingly figured wood.

Softwood grades

- Although cabinetmakers generally prefer hardwoods, numerous fine pieces of furniture have been built with softwood.
- There are good reasons for utilizing hardwood's less expensive cousin:
- Softwood is generally more readily obtainable than hardwood, and is easy to work.
- Pine is one of the most popular choices of cabinetmakers.
- It varieties include Eastern white pine, Southern yellow pine and species from the West, such as sugar pine, Idaho white pine and ponderosa pine.
- Douglas-fir, another Western softwood, is also gaining popularity as a cabinet wood.
- Sitka spruce and Western larch are two other good choices.
- For cabinetmaking, you should restrict yourself to grades of softwood.
- Recall that softwoods are generally sold S4S-that is, planed smooth on both faces and jointed on the edges.
- And they are graded based on the board's best face after surfacing.

- Unlike hardwoods, softwoods are graded differently depending on the species; the grade for a California redwood board, For instance, does not apply to a piece of ponderosa pine.
- You can obtain information about softwood grading standards from the American Lumber Standards Committee in Germantown, Maryland.
- Softwood grading takes both strength and appearance into account.
- Three grade categories-Select, Finish and Common-are often used for woodworking.
- Select and Finish grades must be clear of defects, while boards in the Common grades may comprise defects such as tight knots.
- Select and Finish stock are seasoned to a moisture content of 15 percent or less.
- Common boards, used mainly in building and homebuilding, may have up to a 19 percent moisture level.
- The quality of Common grade boards is further divided into categories 1 to 5, with the highest number corresponding to the lowest grade.
- The stamp displays information about the species, moisture content when surfaced and grade of the stock.
- To avoid marring their appearance, nevertheless, 1 inch thick boards in the better grades are often not stamped after surfacing.
- The stamp may also be missing from lesser grade boards that have been cut into shorter lengths by retail lumber dealers.
- Keep in mind that softwood is sold according to nominal size, or green dimensions, which is different from a board's actual size.
- A 2 by 4, For instance, essentially measures 1 ½ by 3 ½ inches.

Chapter 10 – Understanding lumber effects

Most lumber defects adversely affect a board's appearance, strength, workability or ability to take a finish. Sometimes, nevertheless, irregularities or abnormalities can essentially make a piece of wood more desirable, especially when they develop a popular, distinctive figure like bird's eye or burl.

Of course, intended use is the final arbiter; what maybe a blemish to one woodworker is another board's selling point. Knots, For instance, would be a significant defect in boards intended for a table top, but they are an essential feature of some versions of paneling.

Lumber defects are either natural, man-made or the outcome of poor seasoning. All wood harbors natural defects that are caused by growing conditions or qualities of the species itself.

The same type of defect may be present in different woods. Some imperfections are found in all species. Loose knots, For instance, are caused simply by the way trees grow.

They are the remnants of broken branches that have become encased by the growth of new wood. Other natural defects include gum in hardwoods, witch in softwoods and reaction wood in all species.

Natural forces such as fire, wind, fungi and insects can also cause defects in wood. A common defect of this sort is blue stain. Several defects occur when wood is exposed to the air and allowed to dry.

Because wood does not shrink uniformly in all dimensions, warping can outcome when the moisture content of lumber drops below a certain level. Some common seasoning defects are checks, bow, cup, twist, crook and split.

Keep in mind that these defects can also occur in boards cut close to the pith of a log. Some common defects are explained in the chart below and opposite. Although it is virtually impossible to buy wood that is completely defect-free, you can increase your chances of obtaining the best lumber for your needs by selecting your wood carefully.

Another point to review is that you can salvage some lumber with defects if you have access to the necessary tools and learn how to use them.

Defect versions in wood

Defect type: Tight knot

- Description: Seems as a whorl that is intergrown with the surrounding wood tissue. Knots form as the girth of the tree increases, gradually enveloping the branches. If the branches are still alive at the time of their envelopment, the knot integrates with the wood in the tree trunk.
- Treatment: Does not seriously weaken a board; can be cut out or used, as appearance dictates

Defect type: Loose or dead knot:

- Description: Seems as a whorl encircled by a dark ring. When a branch dies the remaining stump is ultimately enveloped by the trunk. But the dead stump cannot integrate with the tissue surrounding it, creating a loose or dead knot,
- Treatment: Eliminate knots before working with the lumber.

Defect type: Gum

- Description: An accumulation on the surface of the board or in pockets within the board. Typically develops when a tree has suffered an injury, exposure to fire or insect attack.
- Treatment: Do not use where a quality finish is required, as gum will bleed through most finishes.

Defect type: Checks

- Description: Lengthwise ruptures or separations in the wood, typically caused by rapid drying. May compromise strength and appearance of board.
- Treatment: Can be cut off.

Defect type: Bow

- Description: An end-to-end curve along the face, typically caused by improper storage of lumber. Introduces internal stresses in the wood that make it hard to cut.
- Treatment: Flatten bowed boards on the jointer, or cut into shorter pieces, then use the jointer.

Defect type: Cup

- Description: An edge-to-edge curve across the face, typically caused when one face of a board dries more rapidly than the other. Common on tangentially cut stock, on boards cut close to the pith, or if one face of a board has less contact with the air than the other.
- Treatment: Cup may correct itself if both faces are allowed to dry to the same moisture content. Cupped boards can be salvaged on the band saw.

Defect type: Twist

- Description: Uneven or irregular warping where one corner is not aligned with the others. Outcomes from uneven drying or a cross grain pattern that is not parallel to the edge.
- Treatment: Board can be salvaged on joiner, or cut into shorter boards.

Defect type: Crook

- Description: End-to-end curve along the edge, caused by incorrect seasoning or having the pith of a log close to the board edge. Weakens the wood, making it unsuitable for weight-bearing applications.
- Treatment: Board can be salvaged on jointer or table saw.

Defect type: Split

- Description: Similar to checks, appearing as separations along the growth rings. Also known as ring confirm or ring shank.

Outcomes from improper drying of wood or felling damage.

- Treatment: Board can be used, but split may mar the appearance of the wood, becoming more noticeable when stain is applied.

Defect type: Machine burn

- Description: Seems as a dark streak across the faces or edges of lumber. Occurs when planer knives are dull or spin on one part of board for too long.
- Treatment: Eliminate machine burn with jointer or sander.

Defect type: Blue stain

- Description: Seems as a discoloration of the surface on otherwise normal-looking wood. Outcomes from molds that flourish when lumber is dried or stored in warm, moist or poorly ventilated conditions. Species like holly and English sycamore are prone to blue stain.
- Treatment: Conceal with a dark stain.

How to recognize reaction wood

- Reaction wood is characterized by its compressed growth rings and silvery, lifeless color.
- It occurs when a tree trunk has a pronounced curve, as often happens when a tree grows on a slope.
- This defect can also be seen in boards cut close to the pith of a trunk.
- Working with reaction wood poses issues for the woodworker; because it has different shrinkage properties than normal wood, the internal stresses in the board can cause a saw blade to bind and kick back.
- When the wood is cut or sanded, it has a fuzzy surface and absorbs stain unequally.
- Bending reaction wood or placing any load on it may cause it to break across the grain.

Chapter 11 – How to prepare the lumber

- The first job in a cabinetmaking venture involves preparing your stock.
- If you own a jointer, a planer and a table saw you can do the work yourself.
- Whether to construct a large cabinet or a miniature jewelry box, lumber is generally prepared in the same way.
- The procedures you follow depend on how the wood was surfaced before you bought it.
- For rough boards, you start by smoothing one face on the jointer, then one edge.
- This will give you adjoining surfaces that are perfectly square to each other.
- Then, pass the second face through a planer so that the faces are parallel.
- Now you can rip your boards to width and crosscut them to length.
- For S2S lumber, which has already had both face surfaced, you need just pass one edge across the jointer, then rip and crosscut.
- S4S wood, with all four surfaces dressed, can be cut to width and length immediately; just edges that will be glued together need to be jointed.
- Although lumber with defects should be avoided, you may find yourself with a few warped boards you do not want to discard.
- A cupped board can be ripped into several narrower pieces, in effect flattening the curve into strips that can be jointed.
- A crooked or bowed board can be salvaged on the jointer by gradually cutting away the high spots.
- And a straightforward jig can be used with the table saw to transform a board with an uneven edge into a square piece.

How to joint a board

- Set a cutting depth between 1/16 and 1/8 inch.
- Joint a board face.
- To joint an edge, feed the stock slowly across the cutter head, making sure that the knives are cutting with the grain.

- While feeding the work piece over the knives, use a hand-over-hand motion to keep downward pressure on the piece just to the outfeed side of the cutter head, maintaining pressure against the fence.
- Continue these movements until you finish the cut.

How to plane stock

- Set a cutting depth up to 1/16 inch.
- Stand to one side of the planer and use both hands to feed the stock carefully into the machine, keeping the board edges parallel to the edges of the planer table.
- Once the machine grips the board and begins pulling it across the cutter head, support the trailing end to keep it flat on the table.
- As the cut progresses, move to the outfeed side of the planer and support the piece with both hands until it clears the outfeed roller.
- If you are making several passes to decrease the board's thickness, plane the same amount of wood from both faces.
- This will minimize warping.

How to rip cupped stock into narrow boards

- This technique for salvaging cupped boards involves the band saw, but you can achieve the same outcome with a table saw or a radial arm saw.
- If you are utilizing a band saw, install your widest blade and set up a rip fence on the machine's table.
- Set the width of cut; the narrower the setting, the flatter the resulting boards.
- To make a cut, set the board convex (high) side up on the table and, butting the board against the fence, feed it steadily into the blade.
- Ensure that neither hand is in line with the cutting edge.
- Finish the cut with a push stick.
- Eliminate any remaining high spots on the jointer.

How to joint concave and convex surfaces

- Extreme crook should be straightened on a table saw.
- On the jointer, the idea is to pass the high spot on the board's edge repeatedly across the cutter head until the edge is straight.
- For the convex, or outward-bowing, edge, pass the high spot at the middle of the board across the knives as numerous times as necessary.
- Avoid "nose-diving," or allowing the leading edge to ride up during the cut.
- When the surface is flat, make a final pass along the entire edge.
- To flatten the concave, or inward-bowing, edge, joint one end of the board as numerous times as necessary, and then turn the board around to repeat the procedure at the other end.
- This operation is similar to basic jointing, except that you just cut the high spot at the trailing end of the board.
- Start the cut with the leading end of the board an inch or so above table level.
- Feed the piece toward the cutter head with just the trailing end in contact with the infeed table.
- When the deepest part of the concave edge is above the knives, lower the leading end of the board onto the outfeed table and complete the pass.
- Once the surface is even, make a final pass the length of the board.
- Flattening bowed stock is similar to face jointing: with the board concave face down, make as numerous passes as necessary to eliminate the high spots near the ends.
- Use push blocks to keep your fingers safely away from the cutter head.

Chapter 12 – The procedure of veneering

The time honored technique of veneering can transform a straightforward cabinet door into a flamboyant burst of color and grain, an unassuming piece of furniture into a seamless work of art.

And though wood veneers have shifted in and out of favor over the centuries, woodworkers have used them to marvelous effect since the ancient Egyptians embellished objects with thin sheets of precious woods.

In the 18th and early 19th Centuries, fine veneers became the hallmark of sophisticated, high-style furniture. Large swaths of distinctive wood veneers covered tabletops; marquetry pictures-delicate patterns made by aligning pieces of veneer and inset ting them in the surrounding wood-decorated all manner of cabinetry.

Veneering declined with the advent of production machinery in the 19th Century, just to rebound once again in the early 20th Century with advances in manufactured board technology and improved adhesives. As supplies continue to improve, veneering makes more sense than ever.

Furniture that would be prohibitively expensive to craft from solid exotic woods can be veneered with the same woods at a much more reasonable cost.

And, of course, veneering today offers the same esthetic advantages it always has. With veneers, woodworkers are free to create stunning grain patterns with such techniques as book matching or slip-matching; they can arrange veneers in an array of appealing configurations-herringbone and reverse-diamond among others.

They can also take full advantage of such beautiful but unstable wood cuts as crotch and burl, which are impossible to work with in solid form. The old masters veneered over a solid-wood base, or substrate, utilizing hot glue made from animal hides, blood and bones.

They smoothed the veneer and pressed out air bubbles with special hammers. While hammer-veneerings still practiced, today's craftsmen may select a more modern veneer press; they can also select from a much wider selection of glues and substrates.

The glue maybe an aliphatic- or plastic-resin type; the substrate may be any one of a number of manufactured boards, most popularly plywood,

particleboard or medium-density fiber board.

The introduction of these manufactured boards revolutionized furniture design: Because the boards are dimensionally stable-they neither swell nor shrink with seasonal changes in humidity-traditional frame-and-panel designs can be substituted by large unbroken veneered surfaces.

Of the diversity of manufactured boards, cabinetmakers perhaps make the most use of plywood, itself a product of veneer building. Plywood is obtainable in numerous grades for numerous uses; always buy the best you can afford.

Cabinet-grade hardwood plywood, which is already faced with eye-catching veneers, is a cost-effective alternative to solid wood-ideal for such ventures as wall and floor cabinets, bookcases and drawer fronts.

Veneers

- Veneer revolutionized furniture making as far back as 2000 bc, when the Egyptians handsawed thin sheets of wood and then adhered them to denser backings with animal glue and heated sandbags.
- Veneering soon advanced into a refined art and became a hallmark of numerous furniture styles.
- The rococo styles of the Louis XV period in the mid 1700s fostered a demand for kingwood, tulipwood, purple heart and rosewood veneers, while the Arts and Crafts movement of the late 1800s ignited a craze for marquetry based on mahogany, walnut and satinwood veneers.
- By the turn of the 20th Century, modern veneer mills served both the furniture and building industries.
- Almost as fragile as an eggshell and bursting with the warmth and opulence of exotic hardwoods, veneers are obtainable in more than 200 varieties, some cut as thin as 1/100 inch.

Some of the most popular varieties are listed below.

- Avodiré: Golden yellow to gold; mottled figure, Medium textured; easy to work. Stains unequally.

- Black walnut: Light gray-brown to dark purplebrown; striped figure, Medium texture; grain hard to work. Takes finish well.
- Brazilian rosewood: Chocolate to violet and black to brick-red; striped figure, Medium texture and oily; hard to work. Resists finish.
- Carpathian elm: Brick red or greenish-brown to light tan; burl figure, Medium texture; easy to work. Takes finish well.
- Imbuia: Rich chocolate to olive-brown and gold; burl and striped figure, Medium texture; easy to work. Takes finish well.
- Lacewood: Silvery pink to reddish-brown, fleck figure, Medium texture; easy to work. Takes finish well.
- Mahogany: Light pink to reddish-brown, striped and fiddleback figures, Coarse texture, hard to work. Takes finish well.
- Maple: Creamy white sapwood with tan heartwood; curly and bird's eye figures, Fine texture; hard to work. Takes finish well.
- Myrtle burl: Golden brown to yellowish-green; mottled and burl figure, Fine texture; moderately hard to work. Takes finish well.
- Olive ash burl: Creamy white with dark brown streaks; burl figure, Coarse texture; easy to work. Takes finish well.
- Pearwood: Rosy cream; straight-grained figure, sometimes curly, Fine texture; easy to work. Takes finish well.
- Purpleheart: Deep purple with light gray sapwood; striped figure. Coarse texture; hard to work. Takes finish well.
- Sapele: Reddish brown; mottled and ribbon stripe figures. Medium texture; easy to work. Takes finish well.
- Ceylon satinwood: Golden yellow; mottled figure. Fine texture; easy to work. Takes finish well.
- Yew: Warm orange with darker streaks; burl figure. Fine texture; easy to work. Takes finish well.
- Zebrawood: Cream background with dark brown lines; striped figure. Medium texture; moderately hard to work. Takes finish well.

Log cut into veneer

- Once its bark is stripped away, a log can be cut into veneer in one of three ways: saw cutting, rotary cutting or flat slicing.

- Saw cutting, which goes back to the early 19th Century, employs huge circular saws to rip strips of veneer from logs.
- Although not as efficient as other techniques, saw cutting is still used to develop some crotch veneers from irregularly grained or dense woods such as ebony.
- Rotary cutting and flat slicing can develop veneers as thin as 1/8 to 1/120 inch and as long as 18 feet.
- In rotary cutting, a log mounted in a huge lathe rotates against a pressure bar while a razor-sharp knife peels off a continuous sheet of veneer the length of the log.
- Fir plywood, as well as some decorative veneers such as bird's-eye maple, are typically rotary cut.
- Half-round, rift and back cutting are variations that develop veneer from half-logs rather than whole ones.
- In flat slicing, a half-log is held onto a frame that swings up and down against a stationary horizontal knife; a slice of veneer is eliminated with every down stroke.
- Flat slicing produces crown-cut veneers.
- A type of flat slicing known as quarter-cut slicing is used on woods that display a striking figure when quartersawn, as in sapele, white oak or lacewood.

Veener versions and sizes

- Rotary cut: Length up to 10 feet; width from 8 to 36 inches.
- Flat-sliced: Length 3 to 16 feet; width from 4 to 24 inches.
- Quarter-cut: Length 3 to 16 feet; width from 3 to 12 inches.
- Butt and stump: Irregular dimensions. Sheet sizes vary from 10 x 36 to 18 x 54 inches; regular sheet size 12 x 36 inches.
- Crotch: Length from 18 to 54 inches; width from 10 to 24 inches; regular sheet size 72 x 36 inches.
- Burl: Irregular dimensions. Sheet sizes vary from 8 x 10 to 18 x 54 inches; regular sheet size 16 x 24 inches.

Shop made veneer

1 - How to setup the cut

- To cut veneer on the band saw, first make a pivot block from two pieces of wood joined in a T, with the outer end of the shorter piece trimmed to form a rounded nose.
- Install a $\frac{3}{4}$ inch resaw blade on the saw and install the rip fence on the table.
- Screw the pivot block to the fence so that the rounded tip is aligned with the blade.
- Position the fence for the width of veneer you want, typically $\frac{1}{8}$ inch.
- If the stock you are cutting is rather thin, clamp a feather board to the table to support it during the cut.

2 – How to cut the veneer

- Feed the work piece into the blade with both hands, keeping the stock flush against the tip of the pivot block.
- To prevent the blade from drifting off line, steer the trailing end of the work piece.
- Near the end of the cut, move to the back of the table with the saw still running to finish the pass.
- Holding the stock square against the pivot block, pull it past the blade.

Veenering

- Applying veneer is like woodworking in reverse.
- Instead of starting with a board, then cutting and sanding it down to its completed dimensions, veneered pieces are built up a layer at a time.
- Beginning with a substrate-or base-of solid wood or a manufactured panel, you glue banding to the edges and then wider pieces of veneer to both faces.
- With a plywood base, orient the grain of the veneer so that it is perpendicular to the grain of the plywood, and both faces of the plywood must be veneered to prevent cupping.

- Never apply veneer over fir plywood, because the grain of the fir can be seen through the veneer.
- With a hardwood base, veneer should be applied parallel to the grain.
- Furniture-quality particleboard and medium-density fiber board also make good substrates for veneering.
- Since these supplies have no grain as they are made of wood particles pressed together with an adhesive, you may arrange the veneer on the panels anyway you wish.
- But the lack of a grain direction is also a disadvantage:
- Neither of these merchandises is as robust as plywood, and any joints cut in them must be reinforced with splines made of some other material.
- Brittle veneers must be applied over a denser underlay veneer such as poplar.
- Always cut the veneer larger than the actual size required, allowing an overhang of about ½ inch all the way around.
- The overhang is trimmed off later.
- If you are pressing down veneer the traditional way-with a veneer hammer-use hide glue, which is reheatable.
- Otherwise, white glue is your best choice. Whichever adhesive you employ, it will be effective just if the veneer is flat, clean and dry.
- Veneer can also be pressed down in a veneer press.
- Newer commercial vacuum presses feature a pump that sucks the air out of a plastic bag that surrounds the substrate and veneer, allowing atmospheric pressure to hold the veneer in place.

How to apply the veneer

1 - Gluing down edge banding

- Cut four strips of banding for the edges of the substrate panel from the same veneer you will use for the faces.
- Make the strips overlap the panel edges by about ½ inch, and be sure their grain will run along the edges, rather than across them.
- Secure the panel in a vise, and then apply a thin bead of glue to an edge.

- Use a small brush to spread the adhesive equally, and then center the banding over the edge.
- Lay a strip of wax paper over the banding and then, utilizing wood pads to protect the edge and faces, clamp the banding down with three-way clamps, spacing them at 6- to 8-inch intervals, until the glue dries.
- Tighten each clamp in turn until a thin glue bead squeezes out.
- Trim the excess banding, and then repeat for the other edges.

2 - Trimming excess banding

- Once the glue has dried, hold the panel on edge on a work surface.
- Butt the back of a veneer saw against the far end of the panel with its teeth on the banding.
- Firmly draw the saw toward you to, trim away the excess banding.
- Ensure the back of the saw remains flush against the face of the panel throughout the cut.
- Turn the panel around and repeat on the other side.
- Excess banding can also be eliminated with a laminate trimmer.

3 - Edging the face veneer

- The edges of adjoining sheets of veneer must be perfectly square if the two pieces are to butt together properly.
- To square them, you will need a shooting board.
- Cut three pieces of $\frac{3}{4}$ inch plywood somewhat longer than the veneer.
- One piece should be wide enough to hold the other two pieces on top and the width of the plane lying on its side.
- Place the two pieces of veneer face to face and sandwich them between the top two plywood pieces so that the edges of the veneer are aligned and protrude by about $\frac{1}{8}$ inch.
- Set the sandwich on top of the third, wider board and clamp the entire assembly to a work surface.
- Run the plane along the shooting board from one end to the other to trim off the venturing veneer.
- Ensure you keep the sole of the plane flush against the edges of

the top plywood pieces during the cut.

4 - Taping veneer sheets together

- If you are pressing down your veneer sheets with a veneer hammer, glue them in place individually.
- If you are applying more than one sheet of veneer to a panel face and utilizing a veneer press to hold them down, tape the sheets together and glue them down as a unit.
- Align the sheets edge-to-edge on a work surface, arranging them good-side up to develop a visually interesting pattern.
- If there are gaps between adjoining sheets, trim the edges on a shooting board.
- The combined length and width of the veneer should exceed the dimensions of the panel by about ½ inch.
- Once you have a satisfactory arrangement, moisten a few lengths of veneer tape with a water-dampened sponge.
- Tape the sheets together across their joints at 6 to 8 inch intervals, and then apply a strip of tape along each joint.
- Press the tape firmly in place with a hand roller.

5 - Gluing down the veneer

- Set the substrate panel face up on a work surface and spread on a thin layer of glue with a small brush or hand roller.
- Do not apply adhesive directly to the veneer; glue will make it curl.
- Recall to use white glue if you are working with a veneer press (step 6); select hide glue if you are utilizing a veneer hammer (step 7).
- Handling the veneer gently, center the sheets over the panel.
- If you taped veneer sheets together, set them taped-side up.
- Ensure the veneer overhangs the edges of the panel equally.

6 - Pressing the veneer in position with a veneer press

- If you are utilizing a veneer press, assemble the device following

the manufacturer's instructions.

- Ensure the spacing between the pipe clamp saddles is somewhat longer than the length of the panel.
- Set the panel on the base of the press veneered face down with a strip of wax paper between the veneered face of the panel and the base.
- Protect the upper face of the panel with wood pads.
- Tighten the press clamps one at a time until a thin glue bead squeezes out from under the panel.

7 - Pressing the veneer in position with a veneer hammer

- If you are utilizing a veneer hammer, set the glued panel veneered face up on a work surface.
- Butt wood scraps against the ends of the panel as stop blocks, then screw them in place.
- Holding the hammer with both hands, work the head of the tool back and forth over the veneer, pressing down firmly and following the grain.
- To eliminate bubbles or to smooth out sections that have not stuck properly, melt the glue by running a household iron over the veneer, then press down again with the hammer.

8 - Trimming the excess

- Once the glue has cured, 2 hours is the typical waiting period-trim the veneer that protects beyond the face of the panel.
- Secure the panel veneered-face up on a work surface, positioning stop blocks as you would when utilizing a veneer hammer (step 7).
- Fit a laminate trimmer with a flush cutting bit, and then rearrange the machine on the panel with the bit just clear of the excess veneer.
- Holding the trimmer with one hand and steadying the panel with the other, turn on the tool and guide it from one end of the panel to the other.
- Repeat for the other three edges of the panel.
- Lightly moisten any veneer tape and eliminate the strips with a

scraper.

Chapter 13 – Utilizing plywood

- Although it may not be as glamorous or as steeped in woodworking tradition as solid lumber, plywood offers several advantages to the cabinetmaker.
- First, it comes in a wide range of standard thicknesses and sizes.
- Second, it is dimensionally stable and is unlikely to warp or display signs of checking or splitting.
- Third, it is obtainable with just about any commonly obtainable veneer on its faces.
- And fourth, it is easy to cut. Indeed, plywood is a good choice for almost any design that does not involve intricate joinery such as dovetails.
- Although veneer has a venerable history and plywood is a rather modern development, first manufactured commercially in the mid 1800s the two are closely related.
- Plywood, after all, is a layered wood material made from thin sheets, or plies, of veneer.
- Decorative plywood is often faced with matched veneers made from high-grade hardwoods such as cherry or walnut.
- The veneer used in building-grade plywood is peeled on a rotary lathe from eight-foot-long logs of poplar, pine or Douglas-fir.
- Both decorative and building-grade plywood are manufactured with an odd number of plies, giving the sheet a balanced building.
- Three plies are typically the minimum number.
- Beneath the face and back veneers of a typical sheet are layers known as crossbands.
- The grain of each crossband runs at right angles to that of adjacent plies to counter wood movement.
- The outcome is a warp-resistant board that is equally robust across both dimensions.
- Some plywoods are also obtainable with reinforced cores.
- As with solid lumber, plywood is obtainable in both hardwood and softwood varieties, although the terms refer strictly to the face and back veneers.
- Hardwood plywood is a stable and cost effective alternative to solid wood, and is used in woodworking applications where

appearance matters, such as for cabinets, drawer fronts and furniture.

- Softwood plywood is generally used for carcass building, bookcases and shelving.
- Not all plywoods are created alike.
- More than 70 wood species are used in its manufacture.
- Plywoods are grouped according to strength and resilience; both softwood and hardwood varieties are obtainable in four groups or categories that are typically stamped on the sheet.

Group 1 (softwood) and Category A (hardwood) species are the robustest and most durable; Group 4 and Category D are the poorest grades.

Softwood Category

- Softwood Group 1: American Beech, Yellow Birch, Douglas-fir, Western Larch, Sugar Maple, Longleaf Pine, Shortleaf Pine, Southern Pine, Tanoak.
- Softwood Group 2: Port Orford Cedar, Cypress, Balsam Fir, Lauan, Black Maple, Virginia Pine, Yellow Poplar, Black Spruce, Sitka Spruce.
- Softwood Group 3: Red Alder, Paper Birch, Alaska Cedar, Eastern Hemlock, Bigleaf Maple, Jack Pine, Ponderosa Pine, Redwood, White Spruce.
- Softwood Group 4: Bigtooth Aspen, Quaking Aspen, Basswood, Red Cedar, Western Cedar, Cottonwood, Sugar Pine, Balsam Poplar.

Hardwood Category

- Hardwood Category A: White Ash, Bubinga, Hickory, Red Oak, White Oak, Pecan, Rosewood, Sapele.
- Hardwood Category B: Black Ash, Avodiré, Black Cherry, Rock Elm, African Mahogany, Honduras Mahogany, Teak, Black Walnut.
- Hardwood Category C: American Basswood, Butternut, American Chestnut, Hackberry, Silver Maple, Eastern White Pine, Western

White Pine, Black Tupelo.

- Hardwood Category D: Bigtooth Aspen, Quaking Aspen, Western Cedar, Fuma, Black Willow.

Plywood versions

- The basic design of all plywoods is the same: a core covered on both sides by layers of crossbanding and a face veneer.
- The most common type has a veneer core.
- All softwood plywoods are made this way, and they are stable, warp-resistant and inexpensive.
- Hardwood plywoods can also be made with solid lumber or particleboard cores.
- The middle ply of lumber-core plywood consists of several narrow strips of solid wood-typically mahogany, poplar or basswood-edge-glued together.
- Particleboard-core plywood has a solid core of particleboard or medium-density fiberboard.
- Lumber-core plywood holds nails and screws best and is preferable when supplementary strength and flatness are required.

Chapter 14 – Plywood grading

The wide array of plywood versions obtainable makes choosing the appropriate one for a venture more involved than simply selecting a particular thickness. Both hardwood and softwood plywood panels are rated depending on how they should be used and on the appearance of their face and back veneers.

They are also obtainable in one of three grades, or resilience ratings depending on the glues and veneers used in the building of the panels. Softwood plywood comes in exterior and interior grades, and a category called Exposure 1.

Exterior-grade and Exposure I plywood are typically made with a waterproof adhesive, creating weather proof panels that are resistant to moisture. Their face and back veneers are cut from a rather weather-resistant wood.

Interior plywood is made with a water resistant adhesive and is typically manufactured with an appearance-grade face veneer and a lesser-grade back veneer.

For most interior applications, woodworkers generally select Exposure I or interior-grade panels. The three hardwood plywood grades are Versions I, II and III.

Type I includes fully waterproof exterior panels while Type II is an interior-grade plywood able to withstand some moisture; Type III is a moisture-resistant interior plywood.

Versions II and III are your best choices for most cabinetmaking ventures. The appearance of the face and back veneers is another factor that differentiates different plywood versions.

Both hardwood and softwood panels are obtainable in six grades. If you are buying softwood plywood you can determine its grade, plus supplementary information about a particular sheet, by reading its grade stamp.

Hardwood plywood is generally not stamped; if you need a particular grade, you have to ask for it and take the supplier's word that you are getting what you want. Plywood is manufactured in a range of sizes.

Softwood plywood ranges in thickness from $\frac{1}{4}$ to $\frac{3}{4}$ inch, while hardwood

plywood is obtainable from 1/8 to 1 inch thick. The standard panel size is 4 by 8 feet, but special orders can be placed for larger sheets.

How to read a grade stamp and edgemark

- Most grade stamps on softwood plywood comprise six basic elements.
- In addition to the American Plywood Association (APA) trademark, the stamp identifies the mill that manufactured the board and the product standard publication that contains the grading rules.
- The hyphenated letters in this case A-D-designate the grades of the face and back veneers respectively.
- The resilience classification may be either exterior, interior or Exposure 1, and the species group number indicates the woods that may have been used in the manufacture of the panel.
- In order to avoid marring a plywood with two good faces A-A grade, For instance an edgemark is used.
- Panel edges sometimes carry color stripes to designate the grade.

Hardwood plywood face veneer grades:

- Premium: Face veneer with well-matched seams and smooth; made of specific hardwood, such as walnut or mahogany. Free of contrasts in color and grain
- Good: Face veneer similar to premium, but not as well matched. Free of sharp contrasts in color and grain.
- Sound: Face veneer smooth, but not matched for color or grain; defects just on back veneer. Generally intended for painting.
- Utility: Veneers have rough grain and may have knotholes up to $\frac{3}{4}$ inch, as well as some discoloration, staining and slight splits. Not matched for color or grain.
- Back: May have larger defects than utility grade, but none that impair panel strength. Not matched for color or grain.
- Specialty: Made to order to meet specific requirements, such as separate panels with matching grain patterns

Softwood plywood face veneer grades:

- N: Sanded smooth; can take a clear finish; face veneer matched for grain and color, free of open defects.
- A: Sanded smooth; can take a natural finish, but is more often painted.
- B: Smooth and sanded; may have minor splits.
- C: Smooth; may have some broken grain, sanding defects and knotholes up to $\frac{1}{8}$ inch.
- C plugged: Sanded; similar to C grade, but knotholes and splits are smaller.
- D: Used mainly for inner plies and back veneer; may have knot-holes up to 2 $\frac{1}{2}$ inches.

Chapter 15 – How to conceal plywood edges

For all its advantages, plywood has one major drawback for cabinetmaking: The multiply composition of the panels is clearly visible on their edges and ends.

Fortunately there are a number of straightforward options for concealing the unsightly plies. Pressure-sensitive wood-grain tape, For instance, can be pressed in place by hand.

Or, self-adhesive edge banding can be applied with an iron. Both merchandises come in several standard widths and wood species. Several more involved edge treatment alternatives ideally suited to custom work.

With the splined miter joint, For instance, the mitered edges of two panels are glued together and reinforced with solid wood splines.

The other techniques involve cutting strips of hardwood banding or molding and bonding them to the edges of the panel. The steps for applying one of these versions tongue and groove edge molding are provided on the following pages.

How to apply self-adhesive edge banding

- Set a household iron on High (without steam) and allow it to heat up.
- Meanwhile, secure the panel on edge in a vise or with clamps, and cut a strip of banding somewhat longer than the edge to be covered.
- Set the banding adhesive-side down on the panel edge.
- Holding the banding in place with one hand, run the iron slowly along the panel edge, pressing the trim flat.
- The heat of the iron will melt the glue and bond the banding to the panel.
- Keep the iron moving; resting it on one spot for more than a few seconds will leave scorch marks.
- Flatten out the banding by running a small hand roller back and forth along the length of the panel edge.
- Shave off any excess banding with a laminate trimmer.

How to make and applying the molding

- Install a combination blade on your table saw and make several passes to cut a groove one third as thick as the panel.
- Then, you need to cut the matching tongue; it should be sawn in the edge of a hardwood board the same thickness as the panel.
- Adjust the blade height so that it equals the amount of stock remaining on either side of the groove.
- Cut the waste from one side of the tongue, then turn the board over and repeat the procedure to complete the tongue; finish each pass with a push stick.
- Cut the piece of molding from the board.
- Finish the job by securing the panel upright in a vise and spreading some glue in the groove and on the tongue.
- Fit the two pieces together (inset) and clamp them in place with three-way clamps.

Chapter 16 – Hardboard versions

Particleboard

- Wood composites such as particleboard and fiberboard are a popular choice for carcase backs, drawer bottoms and concealed panels.
- Made from blends of wood particles and synthetic adhesive bonded together under intense heat and pressure, composite boards are as robust and as durable as most solid woods and generally less expensive.
- They are also more dimensionally stable.
- Particleboard was first advanced in the 1930s as a way of recycling wood flakes, chips and sawdust dismissed as sawmill waste.
- Today, numerous mills focus mainly on particleboard production, processing softwood and medium-density hardwoods into composite particles with machines called drum flakers, chipners and hammer mills.
- Particleboard is manufactured by two techniques: extrusion and mat forming.
- In the less common extrusion procedure, wood particles and adhesives are forced together through a small, thin opening to form panels.
- The grain orientation of the particles is perpendicular to the faces of the panels.
- With mat-forming, the particles and adhesives are squeezed into a mat in a press.
- With this technique, the grain of the fibers is parallel to the panel faces.
- Mat-formed particleboard comes in three configurations.
- Single-layer particleboard features wood particles of uniform size and shape.
- Multi-layer particleboard has coarser shavings at the core of the panel and finer ones on the outside surfaces.
- Graded-density particleboard is similar to multi layer

particleboard, but with a more gradual change from coarse to fine particles.

- Standard particleboard sheets are 4 by 8 feet, although 5-by-10 panels are obtainable; thicknesses range from $\frac{1}{4}$ to 2 inches.

Fibreboard

- Fiberboard, or hardboard, is pressed into mats much like particleboard, but because the wood particles are decreased to individual fibers, the outcome is a thin, hard and dense sheet with smooth surfaces.
- Hardboard comes in three grades: standard, tempered and service.
- Tempered hardboard is harder, heavier and more water-resistant than the two other versions.
- Thicknesses range from $\frac{1}{12}$ to $\frac{5}{16}$ inch.
- Another diversity called medium-density fiberboard (MDF), features a fine surface texture with faces and edges almost as workable as solid wood.
- MDF is obtainable in thicknesses from $\frac{1}{4}$ to $1\frac{1}{4}$ inch and can be bought with veneered surfaces.

Board type characteristics

Plywood:

- Easy to work; fine face veneers need little sanding.
- Face holds fasteners well, but edges often split.
- Bore pilot holes; screw diameter should not exceed one-quarter of panel thickness.
- Premium and good grades of hardwood plywood need little finishing; sound grade can be painted; softwood plywood grades N and A can be painted or completed.

Particleboard:

- Hard to work; use of carbide tipped tools recommended; wear a dust mask when working.
- Hold on fasteners poor; bore pilot holes.
- Use finishing nails and drywall screws.
- Multi-layer particleboard accepts most finishes; other versions not suitable for painting or finishing.

Hardboard:

- Edges easy to rout, shape or groove; sanding of faces not required.
- Use of carbide tipped tools recommended.
- Face of tempered hardboard holds screws well.
- Bore pilot holes and use sheet metal screws.
- Accepts most finishes.

Medium-density fibreboard:

- Edges easy to rout, shape or groove; sanding of faces not required.
- Use of carbide tipped tools recommended.
- Hold on nails excellent; hold on screws poor.
- Can be completed or painted.

Chapter 17 – How to dry and store wood

Moisture changes in wood can cause issues for a piece of furniture, some merely annoying, others quite serious. A freshly cut log can comprise water equal to twice its dry weight; made into a piece of furniture, it can turn stone dry.

This capacity to hold different amounts of moisture, under different conditions causes wood to swell and contract. If this property is not reviewed by the cabinetmaker, a drawer that opens smoothly in the dead of winter can swell and jam shut in the humidity of summer.

A perfectly square carcase cabinet can pull itself apart as humidity levels change from season to season. The amount of water in a piece of wood is often expressed as a percentage of its oven-dry or water-free weight.

For instance, if a 50 pound block of wood drops to 30 pounds after oven drying, the weight of the shed water, 20 pounds-divided by the wood's dry weight 30 pounds is the moisture content of the original piece: in this case, 66 percent.

Wood holds moisture in two ways: as free water in cell cavities and as bound water in cell walls. As wood dries, free water is expelled first. When this is all discharged, the wood reaches what is termed its fiber saturation point (FSP).

At this point, the cell cavities are empty, but the bound water remains, permeating the cell walls. For most woods, the FSP occurs between 23 percent and 30 percent moisture content depending on the species, with 28 percent the regular.

The key point to Recall is that at the fiber saturation point, there is no dimensional change in wood from it's freshly cut size. It simply weighs less. Nevertheless, if the wood dries further, falling below the FSB it loses bound water from its cell walls.

The cells shrink and so does the wood. The more bound water a board loses the more it shrinks. The just way to prevent wood from shrinking is to treat it with a chemical such as PEG-1400. (PEG is an abbreviation of polyethylene glycol; 1400 is the chemical's molecular weight.)

PEG- 1400 diffuses into the wood and replaces the bound water, keeping the

cell-walls fully swollen. The treatment is suitable just for green wood, Nevertheless, and is most popular for use with turning and carving blocks.

Wood gains and loses moisture as the relative humidity in the air around it changes. If the relative humidity rose to 100 percent, a piece of wood would reach its fiber saturation point and be at the same size as when it was milled.

If relative humidity fell to 0 percent the wood's moisture content would drop to 0 percent. Because relative humidity falls between those extremes just a portion of the bound water is lost.

Realistically, the moisture content range of most stock is 5 to 20 percent. From season to season, the relative humidity in a given location can vary 80 percent or more. This is because relative humidity and temperature are closely intertwined.

Warm air can hold more moisture than cold air. As a outcome, when cold winter air is heated, as it is in homes and workshops, its ability to hold moisture increases dramatically.

If there is no added moisture obtainable, the relative humidity plummets to extremely low levels. In contrast, hot summer air can hold a large amount of moisture.

But when cooled indoors, it can hold much less. The outcome can be fairly high relative humidity. Both extremes cause changes in the moisture level of wood and in its size.

You can take several precautions to counteract the effects of changing humidity levels. If you store lumber indoors, try to keep the relative humidity fairly continuous, utilizing a dehumidier, For instance, when the levels get too high.

And although you may not be able to control the environment where your furniture will end up, you should build the piece to compensate for wood movement.

When cutting a panel for a frame, for instance, leave a $\frac{1}{4}$ inch gap in the grooves that will house the panel. The extra space will allow the panel to expand and contract as humidity levels rise and fall.

How to relate a wood's equilibrium moisture content to relative humidity

- Whether wood is in the form of a log, a kiln-dried board or a completed piece of furniture, its moisture content varies with the relative humidity of the air around it.
- As humidity rises, so does the wood's moisture content, expressed in percent.
- The moisture level of a piece of wood ultimately reaches its equilibrium moisture content (EMC) after the humidity stabilizes.
- The EMC also varies depending on the temperature.
- The band covers EMC values for most woods at 70 degrees Fahrenheit.
- Those values decrease somewhat at higher temperatures and increase marginally with cooling.

Tangential and radial shrinkage

- Lumber does not contract uniformly, and the tangential shrinkage is parallel to the growth rings that is about twice the radial shrinkage, which occurs across the rings.
- This difference accounts for the warping of boards and panels as wood expands and contracts with fluctuations in moisture content.
- Shrinkage along the length of a board is typically negligible.
- A 2 by 10 plank that shrinks $\frac{1}{2}$ inch in width, For instance, might lose less than $\frac{1}{16}$ inch along its 8 foot length.

Finding dimensionally stable wood

- The typical amount of shrinkage of various species in both the tangential and radial directions when green wood is dried to zero moisture content.
- Values are typically shown in percent, so a 10 percent value in the tangential column, For instance, means that a 10 inch-wide board would shrink by that amount to 9 inches wide.
- Although tangential shrinkage exceeds radial contraction in every case, no two species shrink by the same amount.
- The regular is 8 percent tangentially and 4 percent radially.
- The T/R ratio indicates the proportion of tangential to radial shrinkage.

- The lower the ratio, the less the differential between the two versions of shrinkage and the more stable the wood.
- Species with rather low ratios, like mahogany and teak, are less susceptible to warping than woods with higher ratios, such as beech.

How to use a resistance-type moisture meter

- To determine the moisture content of your stock, use a moisture meter.
- Set the stock on a work surface and push the metal pins on the end of the meter into the face of the board as far as they will go.
- Twist the dial on top of the barrel until the light turns on and take a reading.
- Repeat at several points and regular the outcomes.
- Alternatively, crosscut the board 12 inches from either end, and take a reading from the freshly cut end grain.
- Most meters are calibrated for wood at room temperature-about 68 degree F.
- Follow the manufacturer's instructions to adjust your outcomes if you are working in temperatures significantly above or below this level.

Solar Kiln:

- The kiln with a roof and front wall of tempered glass, provides a natural drying cycle.
- During the day, warmed by sunlight, the wood dries; at night, the moisture in the wetter core of the stock migrates toward board surfaces, ensuring more even drying.
- Build the kiln according to the amount of wood you plan to dry and the space you have obtainable.
- If you are reutilizing glass parts, such as used patio doors or storm windows, you may wish to base the size of the kiln and its framing on the dimensions of the recycled material.
- The kiln is 5 feet wide, 16 feet long and about 8 feet high.
- Select a sunny location for the kiln, then level the surface and spread gravel over it.
- Lay concrete blocks at 2 to 3 foot intervals as a foundation, and then build a base frame of pressure treated 4 by 4s on top of the blocks.
- The rest of the framing and rafters are constructed with 2 by 4 stock; the floor, walls and door are made of $\frac{3}{4}$ inch exterior-grade plywood.
- Once the base frame is in place, nail the floor on top of it, then construct a stud wall frame for the front of the kiln.
- Cut the studs to length and nail a sole plate to their bottom ends and a top plate at their top ends.
- Recess the front edges of the studs about $\frac{1}{4}$ inches from the front edge of the plates to provide a ledge for the glass panels.
- Make the gap between the center of the studs equal to the width of the panels, spacing them no more than 4 feet apart.
- Set the wall frame upright and nail the sole plate to the floor and base frame.
- Repeat the procedure to make and attach wall frames for the back and sides of the kiln, this time without offsetting the studs from the plates.
- Cut the studs for the side walls so that the roof will have a 4 in 12 slope 4 inches of rise for every 12 horizontal inches.
- Cut the roof rafters to allow a few inches of overhang at the front

and back, then nail the rafters to the top plates, spacing them to fit the glass panels to be installed on the roof.

- Tack fascia boards to both ends of the rafters, leaving a small lip above the top edges of the rafters to hold the roof panels.
- Cover the opening between the fascia and the back wall with a 1 by 4 board as a soffit.
- On the front of the kiln, this space should be left open.
- Then nail the walls to the outside edges of the studs on the back and one side, installing hinges and has locks on one side wall to convert it into a door.
- To install the glass panels on the roof, set them on adjacent rafters, leaving ample space between the panels for screws.
- Then fasten down 1 by 3 wood strips that overlap the edges of the panels to hold them in place.
- To accommodate the glass panels in the front wall of the kiln, cut notches in the bottom edges of the rafters, and then slide the panels up into the notch, resting the bottom of the panels on the sole plate ledge.
- Screw 1 by 3 wood blocks to the front edge of the sole plate to support the middle of each glass panel.
- To keep the air in the kiln circulating, fasten a piece of plywood as a baffle to two adjacent studs on the back wall, leaving an opening between the baffle and the top of the studs for air to enter.
- At floor level, construct a frame on the front of the baffle for an exhaust fan.
- The fan will pull warm air down through the baffle and circulate it through the kiln.
- Install the switch for the fan on the baffle, along with a thermostat to start the fan when the air temperature reaches 80 degree F and a timer to turn the fan off at night.
- To keep the lumber stack off the floor, nail down 2 by 2 support pieces spaced about 16 inches apart.
- Pile the lumber as you would for air-drying, leaving adequate space between adjacent boards and separating the layers of stock with 1 by 2 stickers.
- If you cannot supply electricity to the kiln, leave supplementary space between the boards to ensure adequate air circulation.

- Drying of the wood may take several months; use a moisture meter to confirm on the lumber's moisture content periodically.

Chapter 18 – How to estimate wood movement

Unless you plan to build all your furniture from manufactured boards such as particleboard and plywood, you should expect the wood you work with to swell and shrink somewhat.

This should not cause any issues as long as you compensate for the change of dimensions when you build your piece. A good first step is to measure the moisture content of the lumber.

Then determine how much this moisture level will change as relative humidity fluctuates in the location where the completed piece of furniture will be placed. Lastly, try to estimate the amount of wood movement that will occur as a outcome of the wood's changing moisture content.

As a rule of thumb, plain-sawn lumber will move 0.04 inch per foot of width for every percent change in its moisture content. The value for quartersawn wood is 0.025 inch.

The difference between the two gives a good indication of why cabinetmakers select quartersawn over plain-sawn lumber when they want to limit wood movement.

If, For instance, you use plain-sawn white pine with an equilibrium moisture content of 12 percent in summer which dries to an EMC of 8 percent in winter, you can count on as much as 0.16 inch of movement in width per foot between the two seasons. Changes in length are negligible enough to be discounted

To avoid confusing different batches of wood, mark the ends of each board with the species and the date you stacked it. It is also a good idea to treat the ends of the boards with an impervious coating such as hot paraffin wax, varnish, diluted glue or a commercial end sealer.

Otherwise, the ends of boards may dry more rapidly than adjoining surfaces, causing checks to form in the wood. If you are working with logs, coating their ends will increase the amount of usable lumber the logs will yield by as much as 20 percent.

Whatever the size or location of your drying stack, air must circulate equally around all the surfaces of the stock. This will ensure that the surfaces of the boards stay dry enough to prevent fungi from causing blue stain.

It will also help guarantee a minimal amount of warping of the boards. Placing stickers, or narrow strips of wood, between different layers of stock exposes the top and bottom surfaces of the boards to the same flow of air.

Lumber can be air-dried indoors or outdoors, but for best outcomes, you should start the procedure outside or in an unheated building like a barn or garage. In a heated indoor location, where humidity is typically low and temperatures are high, green wood may dry too rapidly, which promotes checking.

Outdoors, the lumber should be covered with a sheet of plywood to serve as protection from the elements. As the wood dries, confirm its moisture content periodically with a meter, keeping notes for future reference.

Wood destined for outdoor use need just be dried outside. For indoor furniture, the wood should complete its drying inside, preferably at a humidity level similar to that in the location where the furniture will ultimately be used.

Drying times for various woods

- The below charts indicate the drying time for a stack of 1-inch-thick green boards outdoors.
- The low end of the range for each species is for lumber stacked in spring or summer-prime drying weather.
- The high end is for lumber stacked in autumn or winter.
- The figures assume that the lumber is dried in a region with a climate similar to that where the wood was cut.

Drying times for hardwoods:

- Ash, white - 60-200 days
- Basswood, American - 40-15 days
- Beech, American - 70-200 days
- Butternut - 60-200 days
- Cherry, black - 70-200 days
- Elm, gray - 50-150 days
- Hickory - 60-200 days
- Maple, sugar - 50-200 days

- Oak, red - 70-200 days
- Sycamore, American - 30-150 days
- Walnut, black - 70-200 days

Drying times for softwoods:

- Douglas-fir - 20-200 days
- Hemlock - 60-200 days
- Pine, Eastern white - 60-200 days
- Pine, sugar - 15-200 days
- Redwood - 60-365 days
- Spruce, red - 30-120 days

Two options for air- drying lumber

- To air-dry a large quantity of lumber, start your stack with two 4 by 4 supports equal in length to the boards to be dried.
- Rest the supports on concrete blocks.
- Then place 4 by 4 bolsters at 3-foot intervals across the supports.
- Begin stacking your lumber at right angles to the bolsters, leaving a space between each piece equal to the board thickness.
- Separate each layer with a 1 by 2 sticker as long as the width of the stack; cut the stickers from dry heartwood.
- Thinner stickers will slow the drying time for hard species like white oak.
- Align the stickers with the bolsters; if you are drying thin stock, place the bolsters and stickers closer together to prevent the wood from warping.
- Cover the top row of stickers with plywood, topped with a pair of concrete blocks to apply uniform pressure on the stack and protect it from rain.
- Stack smaller quantities of lumber in support frames made from four pieces of 2 by 4 stock nailed together.
- Build a frame for each end of the stack and one for every 3 feet of board length.
- The frames should be somewhat wider and higher than the stack.
- Arrange the boards as you would for a larger stack, separating

each layer with stickers.

- Space the stickers at 18 inch intervals, aligning one with each frame and also centering them between the frames.
- To keep the stack pressed down firmly, insert wedges firmly between the frames and the top row of stickers.

Chapter 19 – How to store wood

Whether you wish to store lumber, manufactured boards, dowels or "shorts"- all those odd-sized pieces you cannot afford to toss out you should find a storage option to suit your needs on the pages that follow.

The dimensions provided are given strictly as guidelines. Each design can be adapted to any situation. The just design element you cannot skimp on is adequate support for the rack.

A dozen 10 foot-long planks of 6/4 white oak can weigh as much as 400 pounds. Rack supports should be secured directly to wall studs or to the joists above the ceiling at no more than 40 inch intervals.

In most homes with 16-inch on center framing, this means tying into every other stud or joist. If the walls and ceiling of your shop are completed, use a stud finder to locate these framing members.

Some racks, like the cantilever type, may need footings, joist supports or both. If space is at a premium in your workshop, you need to review the design and placement of your wood storage system carefully. The end-loading type of rack used at most lumberyards is impractical for storing long stock in most home shops.

You are far better off with a frontloading system, which makes it easier to load up new material and to shift wood around to find the particular plank you want. Avoid utilizing triangular-shaped brackets to support lumber; they waste precious space.

How to build a pipe storage rack

- The storage rack that will be discussed features three piece vertical supports bolted to wall studs.
- The supports buttress the steel pipes, which carry the lumber.
- You will need one support at each end of the rack, with an supplementary one every 32 to 48 inches along the wall.
- Use 2 by 6 stock for the middle strips of the supports and 2 by 4s for the side pieces; the steel pipes should be roughly 20 inches long with a 1 inch internal diameter.
- Mark cutting lines on the edges of the middle strips at each point

where you want to locate a pipe bracket.

- Ensure all the brackets in the same horizontal row will be at the same height.
- Saw the middle strips for the brackets, angling the cuts by about 3 degree above the horizontal so the pipes will tilt up somewhat to prevent the lumber from sliding off.
- Once all the middle strips are cut, nail on the side pieces, forming brackets with equally spaced notches for the pipe supports.
- Bore pilot holes at 24 inch intervals into the wall studs and drill clearance holes through the supports for 3/8 inch lag bolts.
- Secure the vertical brackets so the studs with bolts that penetrate 2 inches into the wall, then slip the pipes into their notches.

How to make a cantilevered storage rack

- The rack is anchored to the joists in the ceiling to keep it from toppling forward.
- Mark lines on your workshop floor directly under each joist.
- To provide a sturdy base for the posts, nail short lengths of 2 by 6 to the floor as footings, centered on the marked lines.
- Use 4 by 4s for the posts, then cut a joist anchor for each post and as numerous arms as you need from 2 by 6 stock.
- Angle the top edge of the arms somewhat to tilt the lumber in toward the wall.
- Cut a mortise at the top of each post for the joist anchors, and at every point along the post's front edge where you want to locate an arm.
- Ensure all the mortises in the same horizontal row are at the same height.
- Cut tenons at the ends of the joist anchors and arms, and then bore holes through the side of the posts for $\frac{3}{4}$ inch dowels: two holes for each arm and one for every joist anchor.
- Insert the tenons and tap the dowels in place.
- Toe-nail the posts to the footings.
- Bore clearance holes through the anchors and pilot holes into the joists for carriage bolts, and then secure the anchors in position.

How to fasten a lumber-and-plywood rack to an uncompleted wall

- The rack is made exclusively of 2 by 4 stock, is attached to exposed wall studs and ceiling joists.
- Lumber can be piled on the arms, while plywood is stacked on edge against the support brackets.
- You will need at least 8 ½ feet of free space at one end of the rack to be able to slide in plywood panels.
- Begin by cutting the triangular-shaped brackets and screwing them to the studs.
- Cut the footings, lip them under the brackets and nail them to the shop floor.
- Then, saw the upright so length and toe-nail their ends to the footings and the joists.
- Cut as numerous arms as you need, aligning the first row with the tapered end of the support brackets.
- Use carriage bolts to fasten the arms to the studs and uprights, making sure the arms in the same row are level.
- The rack should feature arms spaced at 18 inch intervals.

How to make a freestanding plywood rack

- The rack should hold plywood panels on edge without any wall support.
- Cut the bases and legs from 2 by 4 stock and nail the pieces together.
- To reinforce the rack, nail triangular braces of ½ inch plywood to the outside legs and the bases; use solid lumber braces to support the legs in the middle row.
- To connect the three sets of legs, cut rails from 1 by 4s and nail them in place: one halfway up the legs and another at the top of the legs.
- Set up the rack where you can slip the panels in and out end first.

How to build a vertical plywood rack

- For long-term storage, stacking plywood on end not just keeps the

panels from warping; it also saves precious shop floor space.

- The rack is built from furring strips, threaded rods and wing nuts.
- Start by screwing two furring strips to the studs of one wall, 2 and 5 feet from the floor.
- Then screw two rods 4 ½ feet apart into the top strip.
- Cut a third furring strip and bore a hole through it 2 inches from one end and saw a notch at an interval of 4 ½ feet.
- Both openings should be somewhat larger than the diameter of the rods.
- Place two wood pads on the floor between the rods and stack the plywood sheets upright on them.
- Place the third furring strip across the face of the last panel, slipping one rod through the hole and the other into the slot.
- Slide washers and wing nuts onto the rods and tighten them, pulling the furring strip firmly against the plywood.
- To eliminate a sheet from the stack, loosen the wing nuts and swing the furring strip down and out of the way.

How to wrap dowels with rope

- Dowels tend to roll around when they are stored flat.
- Stacking them upright is a better alternative, but then the issue is to keep them from sliding down or falling over.
- One answer is to loop them together with a length of rope.
- Drill a hole through a paint can just below the rim and tie one end of the rope to it; form a loop at the other end.
- Drive a column of nails, spaced a few inches apart, into a wall stud a few feet above the can.
- Stand the dowels in the can and loop the rope around them twice.
- Pull the cord tight and hook the looped end on one of the nails that allows the rope to hang taut.
- Move the loop up or down as the size of the dowel bundle changes.

How to store dowels in the ceiling

- The gaps between exposed joists in a shop ceiling are often

reviewed wasted space, but you can make good use of them to hold dowels.

- Screw a couple of 1 by 3 furring strips across the bottom of the joists and then rest the stock on top of strips.
- This technique is particularly useful for long dowels, which can clutter a workshop.

How to construct a rack with a mobile base

- Sorting through a jumbled wood pile in a corner of the shop for a piece of short stock of the right size can be frustrating.
- The rack stores short pieces according to size.
- The bottom section is a box with dividers, ideal for storing pieces of plywood; the box is made with $\frac{3}{4}$ inch plywood, while the dividers are $\frac{1}{4}$ inch plywood.
- The top section, built from $\frac{3}{4}$ inch plywood, consists of a back panel, triangular-shaped sides and $\frac{1}{4}$ plywood shelves spaced according to the diameter of the containers you place between them.
- The rack features 5 gallon cans below the bottom shelf and plastic tubes of varying sizes on the other shelves.
- Keep short stock in the cans and tubing.
- Cut triangular cut outs near the top of the sides to hold dowels flat.
- To make the rack mobile, fasten it to a shop-built dolly with casters.
- Cut a piece of plywood to the same dimensions as the base of the rack, then screw corner blocks to one side.
- Attach a heavy-duty caster to each corner block.

How to make a combination workbench and short-cut bin

- In a workshop with limited space, build a work table with short-cut storage space underneath.
- Cut 2 by 4s to length for the legs; support them with 2 by 4 braces—one set nailed a few inches above the floor and a second set attached flush with the top of the legs.
- Cut the top and two shelves from $\frac{3}{4}$ plywood, and then nail them

to the braces.

- Saw notches out of the curves of the shelves to fit around the legs.
- Make dividers from $\frac{1}{4}$ inch plywood and attach them between the shelves utilizing quarter-round molding strips nailed into the shelves.

How to stack stock between wall studs

- Store short stock between the studs of an uncompleted shop wall.
- To keep the wood from falling over, screw spring clips to the studs and insert dowels into the clips to span the gaps between adjacent studs.
- To stand shorter lengths of stock higher up on the wall, cut shelves and support cleats from scrap wood.
- Screw the cleats to the studs and rest the shelves on top of them.

Chapter 20 – Wood index guide

Trees have formed a part of the Earth's landscape for more than 300 million years since before dinosaurs first roamed the planet. In that time they have advanced a remarkable diversity of species, numbering more than 1000 varieties in the United States alone. Trees come in numerous sizes and shapes, from the stunted spruces of northern Canada to the sublime towering stands of California's giant sequoias.

Wood's diversity is also apparent in the wide array of colors and grain patterns obtainable to the woodworker, from the bold vermilion hue of padauk and the inky blackness of ebony to the intricate, swirling designs of walnut burl. The 21 species of wood shown in this directory were chosen with the needs and interests of the cabinetmaker foremost in mind.

The basic cabinetmaking woods are here—species such as oak, pine, cherry and ash. But there are also a number of less familiar exotic woods too, from afrormosia to ziricote. Some you may have just read about; others you may be seeing for the first time.

In either case, the photos and information may inspire you to new adventures in your upcoming woodworking ventures. The directory is arranged alphabetically according to a wood's most commonly used name.

Sometimes a wood may be known by several names; to avoid confusion you may need to use the botanical name when buying a particular species, indicates that the wood comes from several species belonging to that genus.

The woods in the following chapter were photographed with a clear lacquer finish to highlight their color and figure. For this reason and because of the inevitable variations within species, the uncompleted wood that you buy may look somewhat different.

Some softwoods are essentially harder than some hardwoods. For more information on the differences between the two groups, see previous chapter on differences between softwood and hardwood.

The workability category gives information about the ease or hardy of working with a particular wood. Some species may be tough to plane unless you decrease the angle of the blade, while others may require you to pre-bore for nailing.

Rather than providing a specific cost per board foot, which can fluctuate-for each wood, price is listed on a relative scale, from inexpensive to expensive. Typically, the pricier woods are chosen for a special part of a piece of furniture.

You might select a piece of cocobolo, For instance, to make a drawer pull, or an inlay of ebony to add a decorative touch to a chair leg.

All the woods shown are commercially obtainable in North America; for species you cannot find locally. Nevertheless, some species are becoming increasingly rare, and a few tropical hardwoods are in danger of extinction.

Trade in numerous places is severely restricted, and for this reason, woodworkers often must seek alternatives to utilizing traditional woods. Fortunately, there are numerous, and their number is growing.

Some have long been obtainable: pau ferro, For instance, which is strikingly similar to the costly, endangered Brazilian rosewood. Others so called "good woods," grown and harvested with a view to conservation and sustainable growth are recent arrivals in North America.

These lesser known species, imported mostly from Central and South America at present, originate from sources that are monitored in order to be certified as well managed.

You may want to avoid the issues of scarcity by building your ventures with more plentiful woods or plywood, then covering them with a beautiful veneer.

Another alternative is recycled wood, scavenged from old buildings, shipping crates or pallets. With effort and imagination you can transform numerous workaday items into handsome pieces.

Chapter 21 - Wood index

Afrormosia

- Other names: Assemala
- Source: West Africa

- Characteristics: Straight to interlocked grain, moderately fine texture, yellow-brown, darkens to a rich golden brown with exposure.
- Uses: Indoor and outdoor furniture, boat building, cabinetmaking and decorative veneers.
- Workability: Generally good with all woodworking tools.
- Finishing: Accepts finishes very well.
- Price: Expensive.



Alder, red

- Other names: Western alder
- Source: North America
- Characteristics: Generally straight grain, fine even texture, pale yellow to reddish brown.
- Uses: Turning, furniture, carving, plywood and veneers.
- Workability: Generally good.
- Finishing: Accepts finishes well.
- Price: Inexpensive.



Ash black

- Other names: Brown ash, Water ash
- Source: USA and Canada
- Characteristics: Straight grain, even texture, dark greyish brown.
- Uses: Joinery, cabinetmaking and veneers.
- Workability: Generally good.
- Finishing: Accepts finishes well.
- Price: Inexpensive.



Balsa

- Other names: Guano
- Source: West Indies
- Characteristics: Straight grain, fine velvet texture, white to oatmeal brown with a pinkish tint.
- Uses: Model making, toys and water sport tools.
- Workability: Extremely good if the blades are kept sharp..
- Finishing: Accepts finishes very well.
- Price: Moderate.



Basswood

- Other names: American lime
- Source: USA
- Characteristics: Straight grain, fine texture, creamy white.
- Uses: Turning, carving, making toys, piano keys, boxes and crates.
- Workability: Very good, but poor bending properties.
- Finishing: Generally good with all finishes.
- Price: Inexpensive.



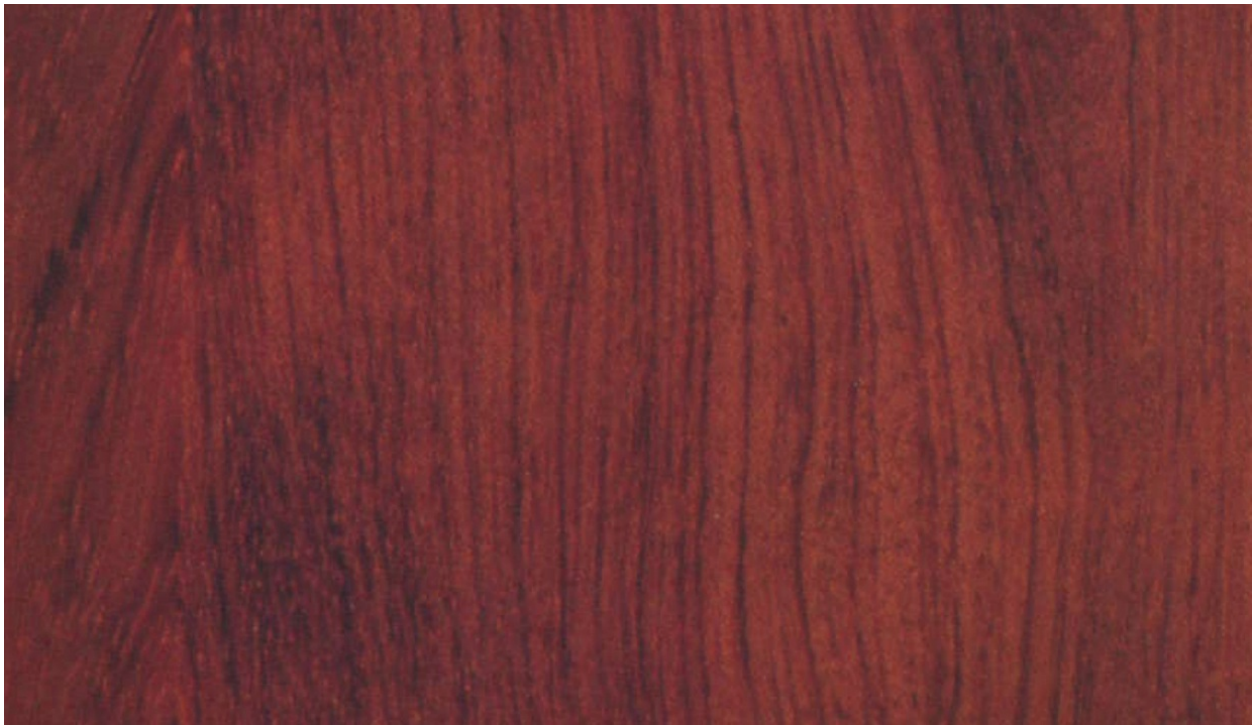
Bocote

- Other names: Cordia
- Source: Mexico, Honduras
- Characteristics: Straight grain, moderately coarse texture, green to golden yellow with black figure patterns.
- Uses: Furniture, cabinetmaking, turning and decorative veneers.
- Workability: Generally good, and good bending properties.
- Finishing: Accepts finishes well.
- Price: Expensive.



Bubinga

- Other names: African rosewood
- Source: Gabon and Cameroon
- Characteristics: Very dense, fine grain, purplish pink to salmon red, with dark purple veining.
- Uses: Turning, furniture, cabinetmaking and veneers.
- Workability: Generally good.
- Finishing: Excellent.
- Price: Expensive.



Cedar, Alaska Yellow

- Other names: Yellow Cedar
- Source: North America
- Characteristics: Straight grain, fine texture, pale yellow.
- Uses: Furniture, joinery and veneers.
- Workability: Very good.
- Finishing: Accepts finishes well.
- Price: Moderate.



Chactacote

- Other names: Redwood
- Source: Mexico and Belize
- Characteristics: Irregular grain, fine texture, crimson red, sapwood cream.
- Uses: Furniture, cabinetmaking and turning.
- Workability: Very good with all woodworking tools.
- Finishing: Accepts finishes well.
- Price: Moderate.



Chontaquiro Amarillo

- Other names: Sapupira
- Source: South America
- Characteristics: Straight to interlocked grain, moderately coarse texture, light to dark brown heartwood, cream sapwood.
- Uses: Furniture, cabinetmaking and a range of building uses.
- Workability: Generally good with all woodworking tools.
- Finishing: Accepts finishes well.
- Price: Moderate.



Cocobolo

- Other names: Granadillo
- Source: Central America
- Characteristics: Heavy dense wood, straight to irregular grain, medium texture, purple, orange, rust and yellow with black markings.
- Uses: Turning, knife handles and tool handles.
- Workability: Generally good but very hard to glue.
- Finishing: Accepts finishes very well.
- Price: Expensive.



Ebony

- Other names: Indian ebony
- Source: India, Africa
- Characteristics: Dense wood, interlocked grain, very dark brown to black.
- Uses: Turning, brush, musical instruments, handles, highly decorative applications.
- Workability: Hard, pre-bore for nailing.
- Finishing: Accepts finishes well.
- Price: Very expensive.



Iroko

- Other names: African teak
- Source: Africa
- Characteristics: Interlocked or irregular grain, even texture, light golden to dark brown.
- Uses: Boat building, cabinetmaking, joinery, outdoor furniture.
- Workability: Generally good with all woodworking tools.
- Finishing: Accepts finishes very well.
- Price: Moderate.



Kingwood

- Other names: Violetwood
- Source: Brazil
- Characteristics: Straight grain, fine texture, violet-brown, dark violet and black stripes.
- Uses: Turning and veneers.
- Workability: Generally good with all woodworking tools.
- Finishing: Accepts finishes well.
- Price: Very expensive.



Madrone

- Other names: Madrona
- Source: Canada
- Characteristics: Straight to irregular grain, fine even texture, pale reddish yellow to deeper red or brown.
- Uses: Fine furniture, turning and decorative veneers.
- Workability: Satisfactory, medium bending properties.
- Finishing: Accepts finishes well.
- Price: Moderate.



Olivewood

- Other names: Italian Olivewood
- Source: Italy
- Characteristics: Straight to irregular grain, fine texture, light to dark brown.
- Uses: Turning and carving.
- Workability: Generally good but hard to saw.
- Finishing: Accepts finishes well.
- Price: Expensive.



Padauk

- Other names: Camwood
- Source: West Africa
- Characteristics: Straight to interlocked grain, moderately course texture, deep red to purple brown.
- Uses: Furniture, cabinetmaking joinery and veneers.
- Workability: Good.
- Finishing: Accepts finishes very well.
- Price: Moderate.



Pear

- Other names: Swiss pear
- Source: Europe and USA
- Characteristics: Straight grain, very fine even texture, pinkish-brown.
- Uses: Carving, turning and decorative veneers.
- Workability: Medium, but excellent turning wood.
- Finishing: Excellent.
- Price: Expensive.



Indonesian Rosewood

- Other names: Shisham
- Source: Southern India
- Characteristics: Interlocked grain, even texture, golden brown to dark purple brown.
- Uses: Fine furniture, turning and veneers.
- Workability: Hard.
- Finishing: Accepts finishes very well.
- Price: Expensive.



Spanish cedar

- Other names: Brazilian cedar
- Source: Mexico
- Characteristics: Straight, often interlocked grain, pinkish to reddish brown.
- Uses: Furniture, boat building, cabinetmaking and decorative veneers.
- Workability: Generally good with all woodworking tools.
- Finishing: Fairly good.
- Price: Moderate.



Zebrawood

- Other names: Zingana
- Source: West Africa
- Characteristics: Interlocked grain, medium to coarse texture, heartwood pale yellow brown with thin darker streaks.
- Uses: Turning, tool handles, cabinetmaking and decorative veneers.
- Workability: Fairly good.
- Finishing: Fairly good.
- Price: Expensive.



Bonus Chapter - List of technical terms

Absolute humidity:

A measure of the weight of water vapor per unit volume of air, typically expressed as grains per cubic foot; see relative humidity.

Air-dried lumber:

Dried lumber that has reached its equilibrium moisture content by exposure to the air.

Angiosperm:

Belonging to the botanical sub-phylum or group of woody plants that have encapsulated seeds such as a walnut or acorn: includes all hardwood tree species.

Annual growth ring:

The visible layer of growth that a tree puts on in a single year, including the early wood and the latewood; seen in the end grain of wood.

Bark:

The outermost layer of a tree's trunk that protects the inner wood and cambium from the elements; composed of the outer, dead cork and the inner, living phloem.

Bird's-eye figure:

Figure on plain sawn and rotary-cut surfaces of a few species of wood-most commonly maple-exhibiting several small, rounded areas resembling birds' eyes; caused by local fiber distortions.

Blister figure:

Figure on plain sawn or rotary cut surfaces that looks like various-sized elevated and depressed areas of rounded contour.

Board foot:

A unit of wood volume measurement equivalent to a piece of wood 1 inch thick, 12 inches wide and 12 inches long.

Book match:

In veneering, a decorative pattern in which successive veneers in a flitch are arranged side-by-side in a mirror formation, like pages of an opened book.

Bound water:

Moisture present in wood found within the cell walls; see free water.

Bow:

A lumber defect in which a board is not flat along its length.

Bucking:

Crosscutting a tree into logs of a desired length.

Burl veneer:

Highly decorative veneer taken from bulges or irregular growths that form on the trunks of some species and on the roots of others.

Butt veneer:

Veneer cut from the area in a tree's trunk just above the roots; also known as stump veneer.

Cambium:

A layer of actively growing tissue, one cell thick, between the phloem and the sapwood, which repeatedly divides itself to form new cells of both.

Cant:

A log that has been debarked and sawn square in preparation for further cutting.

Case hardening:

A lumber defect resulting from drying a board too rapidly; the outer layers of a board are in compression while the inner layers are in tension.

Cell:

The smallest unit of wood structure, each with its own specialized function; cells include vessels, fibers, rays, and tracheids.

Check:

A lumber defect in which splits develop lengthwise across the growth rings during seasoning because of uneven shrinkage of wood.

Clear:

Describes a board face that is free of defects.

Common grade lumber:

In softwood, lumber with conspicuous defects such as red or black knots and pith.

Compression wood:

Reaction wood formed on the undersides of branches and leaning or crooked stems of softwood trees.

Conifer:

Any of several families of softwood trees that bear cones; see softwood.

Crook:

A lumber defect where there is an edgewise deviation from end-to-end straightness in a board.

Crossband:

In plywood with more than three plies, the veneers immediately beneath the

surface plies are oriented with a grain direction perpendicular to that of the surface plies.

Cross grain:

Generally, lumber in which the wood fibers deviate from the longitudinal axis of the board; see spiral grain.

Cross section:

A viewing plane in wood identification seen in the end grain of lumber, cut perpendicular to the axis of the tree trunk: also known as a transverse section.

Crotch veneer:

Veneer cut from the fork of a tree trunk.

Crown-cut veneer:

Decorative veneer that is cut from flitches utilizing the flat slicing technique.

Cup:

A lumber defect in which the face of a board warps and assumes a cup like shape.

Curly grain:

See wavy grain.

Cutting list:

A list of the sizes of lumber required for a specific venture.

Deciduous:

Any of several families of trees that shed their foliage annually; see hardwood.

Defect:

Any abnormality or irregularity that lowers the commercial value of wood by decreasing its strength or affecting its appearance; see warp.

Dendrochronology:

The science of dating past events and changes in environmental conditions by comparative study of annual growth rings.

Diamond match:

In veneering, a decorative pattern formed when successive veneers from the same flitch, typically with a diagonal stripe figure, are arranged in a diamond shape.

Diffuse-porous wood:

Hardwoods in which the pores tend to be uniform in size and distribution throughout each annual growth ring.

Early wood:

The portion of the annual growth ring formed in the early part of the growing season; see latewood.

Equilibrium moisture content:

The moisture content that wood ultimately reaches when it is exposed to a given level of relative humidity and temperature.

Extractive:

Resins and other substances deposited in the heartwood during a tree's growth that impart both color and resistance to decay.

Face veneer:

Veneer used for the exposed surfaces in hardwood and softwood plywood.

Fiber:

A specific hardwood cell type, elongated with narrow ends and thick walls;

contributes to the strength of the wood.

Fiber saturation point (FSP):

A condition in which wood cell cavities are free of all water, yet the cell walls remain fully saturated.

Fiddleback:

An eye-catching figure resulting when wood with curly or wavy grain is quarter sawn; commonly used in the manufacture of stringed instruments.

Figure:

In the broadest sense, the distinctive pattern manufactured in a wood surface by the combination of annual growth rings, deviations from regular grain, rays, knots, and coloration.

Finish grade lumber:

Softwood lumber graded for appearance, not strength, seasoned to a moisture content of 15 percent or less; includes superior and prime categories.

Firsts and seconds:

The top or premium grade of hardwood.

Flat-sliced veneer:

Veneer that is sliced off a log or a flitch with a veneer slicer.

Flitch:

A section of a log cut to extract the best figure and yield of veneers from a log; also known as a cant.

Free water:

Moisture present in wood found inside the cell cavities; see bound water.

Grade stamp:

A stamp applied to most softwood and some hardwood lumber indicating the grade, strength properties, species of wood and the mill that manufactured it.

Grain:

Generally, the direction, size, arrangement, appearance, or quality of the elements in wood or lumber; precisely, the alignment of wood fibers with respect to the axis of the tree trunk.

Green lumber:

Freshly sawn, unseasoned lumber having a moisture content above the fiber saturation point.

Gymnosperm:

A botanical sub-phylum or group of woody plants that have exposed seeds like a pine seed; includes all softwood tree species.

Hardboard:

A type of manufactured board with smoother surfaces than particleboard, made by breaking waste wood down into its individual fibers, mixing them with adhesives, and mat forming them into a robust, homogenous panel.

Hardwood:

Generally, wood from angiosperm tree species.

Headsaw:

The large band saw or circular saw at a mill that cuts logs into large slabs of timber for resawing; also known as head rig.

Heartwood:

The dead, inner core of a tree extending from the pith to the sapwood, typically differentiated from sapwood by its darker color.

Herringbone match:

In veneers, a decorative match created when successive veneers from one flitch, typically with a diagonal stripe, are arranged to form a herringbone pattern.

Humbolt undercut:

A technique of felling trees where a wedge is cut in the stump of a tree rather than in the upper log before it is felled.

Hygroscopicity:

The ability of a substance to readily absorb, retain, and desorb moisture.

Interlocked grain:

Wood that features repeated alternation of left and right hand deviations of fibers from the axis of the tree trunk, typically over several growth rings; outcomes in ribbon figure on quarter-sawn surfaces.

Key:

A master list of wood species used in identification, ordered by criteria such as gross anatomical features, macroscopic features, or microscopic features.

Kiln:

A heated chamber used in drying lumber, veneer, or wood merchandises where temperature, humidity and air circulation are controlled.

Kiln dried lumber:

Lumber that has been dried to a specific moisture content.

Knot:

The base of a branch or limb that has been overgrown by the expanding girth of the trunk or other portion of the tree.

Latewood:

The portion of the annual growth ring formed in the latter part of the growing

season; see early wood.

Lesser known species (LKS) :

Woods recently introduced to the market, such as chactacote, tornillo and chontaquiro amarillo, numerous of which come from sources that practice sustainable forest management.

Linear foot:

A measurement referring just to the length of a piece of wood; see board foot.

Lumber:

Logs that have been roughly sawn into timbers, resawn, planed and sawn to length.

Lumber-core plywood:

Plywood in which softwood and hardwood veneers are glued to a core of narrow, sawed lumber.

Lumber ruler:

A tool used to measure the board-foot volume of a piece of lumber with a flexible wooden shaft and a hook for turning boards.

Luthier:

A builder of stringed musical instruments such as violins and guitars.

Macroscopic features:

Referring to anatomical features of wood identification visible with low-power magnification, typically a 10x hand lens.

Marquetry:

Decorative inlay work done with veneers, metals or other supplies.

Medium density fiber board (MDF) :

A type of tempered hardboard with a fine texture used in cabinetmaking.

Moisture content:

The amount of water contained in wood, expressed as a percentage of the weight of the oven dried wood.

Mottled figure:

A type of broken stripe figure with occasional interruptions of curly figure.

Nominal size:

The rough sawn commercial size by which lumber is known and sold.

Non porous wood:

Wood devoid of vessels, or pores; softwood.

Oven dried weight:

The continuous weight of wood that has been dried in an oven at temperatures between 214 and 221 degree F. to a point where it no longer contains moisture.

Parenchyma:

Thin-walled cells in wood; responsible for the storage of carbohydrates. See ray.

Particleboard:

A type of manufactured board made by breaking waste wood down into small particles, mixing them with adhesives, and extruding or mat-forming them into panels of varying thickness.

Particleboard core plywood:

Plywood in which hardwood and softwood veneers are glued to a particleboard core for added strength.

Phloem:

The inner bark, which distributes nutrients derived from photosynthesis in the leaves.

Photosynthesis:

A procedure by which plants synthesize carbohydrates and other nutrients from water and minerals in the presence of chlorophyll and sunlight.

Phylum:

A botanical group or class of plants.

Pitch pocket:

A pocket found within the grain of some conifers, containing an accumulation of liquid or solid resin.

Pith:

The small, soft core occurring in the structural center of a tree trunk.

Plain-sawn lumber:

Lumber that has been sawn so that the wide surfaces are tangential to the growth rings; also known as flat-sawn lumber when referring to softwood; see quarter sawn lumber.

Plywood:

A manufactured board consisting of an odd number of layers or plies of softwood or hardwood veneer; may also be made with a solid core, see lumber-core plywood.

Pore:

A cross-section of a vessel as it seems on a transverse section of wood; see vessel.

Porous wood:

Wood that has vessels, or pores, large enough to be seen with a hand lens; hardwood.

Quarter-cut veneer:

A veneer created by slicing a flitch to expose the quarter sawn surface of the wood.

Quarter match:

A decorative veneer pattern created by arranging successive veneers from the same flitch, typically with a burl or crotch figure in a circular or oval formation; also known as four way center and butt.

Quarter sawn lumber:

Lumber that has been sawn so that the wide surfaces intersect the growth rings, at angles between 45 and 90 degree; also known as vertical-grained lumber when referring to softwood; see also plain-sawn lumber.

Quilted figure:

A distinctive, blister-like figure found in bigleaf maple.

Radial section:

A viewing plane in wood identification cut across the grain perpendicular to the growth rings and parallel to the wood rays; the plane that extends along the axis of the tree trunk from pith to bark.

Radial shrinkage

Shrinkage that occurs across the growth rings as wood dries.

Ray:

A ribbon-shaped strand of cells extending across the grain from pith to bark that appear as streaks on quarter sawn surfaces: sometimes referred to as medullary ray.

Reaction wood:

A lumber defect caused by stresses in leaning tree trunks and limbs; known as compression wood in softwood, and tension wood in hardwood; characterized by compressed growth rings and silvery, lifeless color.

Relative humidity:

The ratio of the water vapor present in the air to the amount that the air would hold at its saturation point, typically expressed as a percentage figure; see absolute humidity.

Resin canal:

Vertical passages between wood cells in conifers that conduct natural resins and pitch.

Ribbon figure:

Distinctive vertical bands of varying luster found on quarter sawn boards of wood with interlocked grain.

Rift sawn lumber:

Lumber whose growth rings are at angles between 30 and 60 degree to the board face; also known as bastard-sawn lumber.

Ring-porous wood:

Hardwoods in which the pores are comparatively large at the beginning of each annual growth ring, and decrease in size toward the outer section of the ring, forming distinct zones of early wood and latewood.

Roe figure:

Figure formed by short stripes less than 1 foot in length, found on quarter sawn surfaces of woods with interlocked grain.

Rotary-cut veneer:

A continuous sheet peeled from a log or flitch by rotating it on a lathe against

a stationary knife.

Sap:

The water in a tree, including any dissolved nutrients and extractives.

Sapwood:

The outer portion of a tree's trunk extending from the heartwood to the cambium; differentiated from the heartwood by its lighter color.

Sawyer:

The person at a sawmill whose job it is to "read" a log before it is cut and select the appropriate cutting patterns.

Seasoning:

The procedure or technique of removing moisture from green wood to improve its workability.

Selects:

In softwood, defect-free lumber graded for clear appearance rather than strength, separated into firsts and second, C select and D select grades. In hardwood, selects is one grade below firsts and seconds.

Semi-diffuse porous wood:

Wood with pores exhibiting the clear distinction between early wood and latewood that is lacking in diffuse-porous wood, yet not so pronounced a difference as that shown by ring-porous wood; also known as semi-ring porous wood.

Slipmatch:

In veneering, a repeated decorative pattern created by laying successive sheets of veneer from a flitch side-by-side.

Softwood:

Generally, species from the families of trees that have a primitive cell structure, bear cones and for the most part have needle-like leaves; wood manufactured by softwood trees.

Solar kiln:

A kiln that dries lumber with solar energy.

Sound:

Describes a board face free of defects that would weaken the wood.

Specific gravity:

The ratio of the weight of a wood sample to that of an equal volume of water.

Spermatophyte:

Any of a phylum or group of higher plants that redevelop by seed; includes almost all tree species.

Spiral grain:

A form of cross grain caused by the spiral alignment of wood fibers in a standing tree.

Stain:

A discoloration in wood caused by fungi, metals, or compounds.

Sticker:

A piece of wood, typically $\frac{3}{4}$ to 1 inch thick, used to separate boards of lumber in a drying stack to permit air circulation.

Substrate:

A piece of plywood, softwood or hardwood used in veneering as a core.

Surfacing:

The way lumber has been prepared at a mill before it goes to a lumberyard. Also known as dressing.

Sustainable forest management:

The procedure of managing forest land to ensure future productivity and maximize the flow of forest merchandises without placing undue strain on the physical and social environment.

Tangential section:

A viewing plane in wood identification cut along the grain tangential to the growth rings; plain sawn lumber is sawn tangentially.

Tangential shrinkage:

Wood shrinkage that occurs tangentially to the growth rings.

Tension wood:

Reaction wood formed often on the upper side of branches and leaning crooked stems of hardwood trees.

Texture:

Refers to the size of the cells in wood, indicated by adjectives from fine to coarse; often confused with grain.

Tracheid:

Long, fibrous cells that conduct sap and help support the tree.

Twist

A defect caused by the turning or winding of the edges of the board, so that one corner twists out of plane.

Veneer:

A thin layer or sheet of wood sawn, sliced or rotary cut from a log or flitch.

Veneer-core plywood:

Plywood that consists of three or more plies of veneers, each laid at right angles to each other with respect to grain direction.

Veneer press:

A commercial or shop built press used to apply veneers to substrates.

Vessel:

Wood cells of comparatively large diameter found in hardwood, set one atop the other to form a continuous tube for conducting water and sap up the trunk; when viewed in cross-section, vessels appear as pores.

Warp:

A lumber defect or distortion of a piece of wood; see bow, crook, cup, and, twist.

Wavy grain:

Grain resulting from repeated, undulating right and left deviations in the alignment of wood fibers from the axis of a tree's trunk; also known as curly grain.

BOOK 2

HOW TO SETUP
A
SMALL WORKSHOP

Volume 2

Paul Berger

Must have Woodworking Tools

Measuring and marking tools:

- Tape measure
- Steel ruler
- Try square
- Combination square
- Carpenter's square
- Straightedge
- Level
- Chalk line
- Sliding bevel
- Trammel points
- Marking gauge
- Cutting gauge
- Mortise gauge
- Awl
- Dovetail square

Cutting tools:

- Chisels (paring, firmer, butt, mortise)
- Sharpening stone
- Honing guide
- Gouges (wood carving set)
- Router and bits
- Utility knife
- Single edge razor blade
- Scissors
- Wire cutters
- Tin snips

Saws:

- Handsaws (rip, crosscut, backsaw, coping, compass, flush-cutter)
- Miter box with integral saw
- Hacksaw
- Circular saw
- Saber saw

Supplies:

- Nails (finishing, common, box, ring-shank)
- Brads
- Screws (flat, round, and oval head)

- Sandpaper
- Pumice stone
- Steel wool
- Glues (woodworker's, white, contact cement, epoxy, instant)
- Wood putty
- Masking tape
- Pencils and markers
- Wood finishes and appropriate solvents
- Household oil or Penetrating oil
- Sponges
- Rags

Boring tools:

- Push drill
- Hand drill
- Brace
- Gimlet or screw starter
- Electric drill (cordless and corded)

Smoothing tools:

- Hand planes (block, jack, jointer)
- Scrapers
- Files (flat, half-round, round, triangular)
- Rasps (patternmaker's)
- Sanding blocks (flat and contoured)
- Orbital sander

Striking tools:

- Wooden mallets (square and round heads)
- Rubber mallet
- Claw hammer
- Nail sets
- Utility bar
- Tack hammer

Fastening tools:

- Screwdrivers (offset, stubby, cabinetmaker's in flat-, Phillips- and square tip varieties)
- Nut drivers
- Pliers (standard slip joint type)
- Locking pliers
- Channel-joint pliers
- Wrenches (adjustable, open-end)

Clamps:

- Trigger clamps
- Quick-action bar clamps
- Bar clamps
- Pipe clamps
- Spring clamps
- Web clamps
- Hand screws

Finishing tools:

- Foam brushes
- Lint-free cloths
- HVLP sprayer
- Paint scraper
- Molding scraper
- Putty knife

Chapter 1 – Basic Safety tips

For most woodworkers, the home workshop is a peaceful refuge, where craft gives shape to creative ideas. It is also the place where accidents may occur, owing to the very nature of the activity.

But the likelihood of mishap can be decreased by a few straightforward precautions. First, an informed woodworker is a safe woodworker. Read the owner's manuals supplied with all your tools. Before starting a job, ensure that you know how to use the safety accessories that are intended to protect you from injury while working with a tool.

Most accidents are the outcome of carelessness orientation failure to use a safety guard when cutting a board on a table saw, face jointing stock with bare hands, rather than with a push block or utilizing a router without safety goggles.

While the big stationary machines receive most of the attention from safety-conscious woodworkers, there are other potential sources of danger that, though less apparent, cannot be ignored.

Numerous finishing merchandises, particularly those includeing solvents, can be toxic, while their effects may just become apparent after years of prolonged exposure. Certain species of wood can cause allergic or toxic reactions in some people.

Safety goggles, rubber gloves, and a rubber apron are good standard attire for any finishing job, especially if you are spraying a finish or mixing and applying caustic compounds. Fire is another shop hazard. Smoke detectors are an invaluable defence, providing valuable time for you to control the blaze.

Keep a fire extinguisher rated ABC in your shop and know how to use it. One of the leading causes of fire is inappropriate wiring. Whether you are building a shop from scratch or revamping an existing space, electrical safety should be a priority.

No shop should be without the personal safety gear. You can simply make some safety device such as push sticks, push blocks, and feather boards. But do not become complacent about the security they will provide. All the safety tools in the world cannot make a shop accident free.

Safety is foremost a matter of attitude a confidence in utilizing the machines combined with a healthy respect for the power these tools wield. Even with the best efforts at prevention, accident still occurs.

Bits may break, boards split, and shavings fly and all too often find a victim. Being prepared and taking prompt action can help minimize further damage. Take a first-aid course, keep a well-stocked first-aid kit on hand in the shop and be ready to administer medical aid when necessary.

How to prevent accidents

- Wear appropriate safety gear: safety glasses or a face shield, and hearing protectors or ear plugs.
- If there is no dust collection system, wear a dust mask.
- For exotic woods like ebony, use a respirator; the sawdust may cause an allergic reaction.
- Wear work gloves when handling rough lumber.
- Ensure that workshop lighting and ventilation are adequate and that work exteriors are large and sturdy.
- Read your owner's manual before operating any machine.
- Keep children, onlookers and pets away from the work area.
- Unplug a machine before performing set up or installation operation.
- Keep blades and cutter head knives sharp.
- Turn the machine off if it develops an unaware vibration or noise; have the machine serviced before resuming operations.
- Do not use a machine if any part of it is worn or damaged.
- Roll up long sleeves and eliminate rings and other jewellery that can catch in moving parts.
- Keep your hands well away from a turning blade or cutter head.
- Find a comfortable stance; avoid over-reaching.
- Concentrate on the job; do not rush.
- Never work when you are tired, stressed or have been drinking alcohol or utilizing medications that induce drowsiness.
- Keep your work area clean and tidy; clutter can lead to accidents, and sawdust and wood scraps can be a fire hazard.
- Wear safety goggles, hearing protection, work boots and a hard hat. Ensure your clothes are close-fitting and long hair is tied back.

- Operate a chain saw just outdoors on a dry, clear day.
- Mix fuel and add it to the fuel tank at least 10 feet away from your work area.
- To start up the saw, carry it to the work area and set it on the ground; ensure the chain is not contacting anything.
- Brace the tool with your foot and one hand, and use your other hand to pull the starter cord.
- While operating the saw, hold it firmly with both hands.

While a number of high-quality water-based finishes have become obtainable recently, solvent-based finishing merchandises are still widely used, and considered superior for some applications.

Therefore woodworkers must learn to protect themselves against the health hazards associated with organic solvents. Organic solvents can have a number of health effects. Short-term use can outcome in ailments ranging from headaches and nausea to skin and eye irritation.

With extended use, numerous solvents are known to damage the central nervous system or respiratory tract. Some glycol ethers are suspected of causing birth defects, while other solvents, like methylene chloride, have been linked with cardiac arrest.

Solvents can be absorbed into the bloodstream in a number of ways: after being inhaled, or ingested along with food left in the shop, absorbed through the skin, or swallowed when vapors settle in saliva.

Most solvent-based finishes are unlikely to cause harm when used inoften, and are just poisonous if swallowed. But you still need to be aware of the combination and concentration of organic solvents in a particular finish if you plan to use the product in large quantities or over an extended period of time.

The list below provides the solvents comprised in a diversity of finishing merchandises and assesses the relative toxicity of each one. Be sure to select the safest product for the job at hand.

Finishing merchandises and their solvents:

* Safest product

** Mildly hazardous product

*** Product to be avoided if possible

- Wood filler (paste and liquid) -> Solvent: Petroleum naphtha,* mineral spirits,* acetone,** methyl ethyl ketone,** methyl isopropanol, ** isobutyl ketone**
- Stains (aniline, wiping, NGR, gel and glazing stains; color pigments) -> Solvent: Ethanol,* mineral spirits,* toluene,*** xylene,*** methanol,*** glycol ethers**
- Shellacs (white and orange) -> Solvent: Ethanol,* methanol**
- Lacquers (spray and brush, sanding sealers) -> Solvent: Acetone,** methyl ethyl ketone,** isopropanol,** methanol,*** xylene,*** glycol ethers**
- Lacquer thinner -> Solvent: Acetone,** methyl ethyl ketone,** isopropanol,** glycol ethers,*** toluene**
- Rubbing oils (Danish oil, antique oil) -> Solvent: VM&P naphtha,* turpentine,** toluene**
- Drying oils (boiled linseed oil, polymerized tung oil) -> Solvent: Mineral spirits,* turpentine*
- Varnishes (tung oil varnish, spar varnish, varnish stain) -> Solvent: Mineral spirits,* VM&P naphtha*
- Polyurethanes (poly varnish, urethane stains) -> Solvent: Mineral spirits,* toluene***
- Lacquer/varnish removers -> Solvent: Acetone,** xylene,*** methanol,*** methyl isobutyl ketone,*** toluene**
- Waxes (paste wax, furniture wax) -> Solvent: Petroleum naphtha,* turpentine*

As anyone who has suffered through an allergic or irritating reaction to wood dust will testify, working with certain woods can cause serious health risks. The dust from numerous species, like black cherry, Douglasfir, and pine, is known to cause respiratory ailments such as rhinitis (or nasal inflammation) and asthma.

Other woods, including oak, ash, and birch, can irritate the skin and eyes. Some species, like ebony, South American mahogany, and Western red cedar, comprise toxic compounds that can be inhaled, ingested, or absorbed through cuts and scratches.

While the compounds are present in minute quantities, they may cause issues ranging from headaches to regular heartbeat. Protect yourself from direct exposure to wood dust by keeping your shop clean and well ventilated. Wear a dust mask for cutting operations.

When handling a species which you know or suspect may trigger an allergic reaction, spread a barrier cream on your skin or wear protective gear, including gloves, safety glasses, and long sleeves and pants.

Chapter 2 – How to prepare your shop against fire

Considering the number of flammable supplies and potential ignition sources in a woodworking shop, fire prevention should be one of your foremost safety concerns. Sawdust, wood, paint, and thinners tend to accumulate often they are near tools that develop sparks and heat.

The combination can prove volatile: When vaporized in a small enough concentration of air, a small quantity of lacquer thinner, For instance, can be ignited by a spark from a tool and cause a life-threatening explosion.

The first step in fire safety is prevention. All finishing merchandises and solvents, For instance, should be stored away from heat sources in airtight glass or metal containers, preferably in a fireproof cabinet.

Hang rags soaked with flammable compounds to dry outdoors, or soak them in water and store them in sealed metal containers. When working with finishing merchandises, keep window open and the shop well ventilated. Be prepared to deal with a fire effectively.

Install a smoke detector on the shop ceiling or a wall, and keep an ABC fire extinguisher nearby. Design a fire evacuation plan that maps out two possible escape routes from each room of the building in which the shop is located.

If the fire involves an electric tool, a power cord, or an electrical outlet, shut off the power. Call the fire department immediately, inform them of the nature of the fire, and try to extinguish the blaze yourself. But if the flames cannot be contained, or the fire is coming from inside a wall or ceiling, evacuate the building.

How to install a smoke detector

- Open the cover of the detector, hold the base on the ceiling or wall, and mark the screw holes.
- Bore a hole for a screw anchor at each mark.
- Tap the anchors into the holes and, holding the detector in position, drive a screw into each anchor to secure the base.
- Install a battery and close the detector cover.
- Test the device once every month.
- First, press the test button.

- Then, blow out a lit match or candle below a vent, letting smoke enter it.
- Replace the battery if the alarm does not sound for both tests or if it emits a chirping sound, indicating the battery is weak.

Controlling a fire

- To extinguish a small, contained fire, use an ABC rated dry-chemical fire extinguisher, which is effective against all three major classes of fires: burning wood or other combustibles (Class A), oil- or grease-fed flames (Class B), and electrical blazes (Class C).
- Position yourself a safe distance from the fire with your back to the nearest exit.
- Holding the extinguisher upright, pull the lock pin out of the handle (inset) and aim the nozzle at the base of the flames.
- Squeeze the handle and spray in a quick, side to side motion until the fire is out.
- Watch for "flashback," or rekindling, and be prepared to spray again.
- If the fire spreads, leave the building.
- Dispose of burned waste following the advice of the fire department.
- After use, have the extinguisher occupationally recharged; replace it if it is non-rechargeable.

Chapter 3 – How to prepare for electrical safety

Electricity plays a major role in the modern woodworking shop, powering machines and tools, lighting fixtures and lamps, and heating systems. Electricity is so commonplace that it is all too easy to forget its potential for danger.

An electrical shock, even one that can hardly be felt, can be deadly. For this reason, the electrical system is strictly regulated by codes and standards intended to protect you from fire and shock.

Living safely with electricity also requires following basic precautions intended to prevent mishaps. Inspect plugs for cracks and power cords for fraying, and replace any worn or damaged part before utilizing a tool.

Never replace a blown fuse with one of a higher amperage. Do not plug a three-prong plug into a two-slot outlet by removing the grounding prong from a three prong plug.

Instead, replace the outlet with a GFCI. Before undertaking a repair, shut off the power at the service panel. To work on the system, wear rubber gloves and, where possible, use just one hand, keeping your free hand behind your back.

Utilizing GFCI outlets The U.S. National Electrical Code requires that any new outlet in a garage or uncompleted basement must be protected by a ground-fault circuit interrupter (GFCI).

A GFCI protects a circuit-and you-by monitoring the flow of electricity passing through it and tripping instantly when it detects a leak to ground. If you need to replace an outlet in your shop, install a GFCI, following the manufacturer's directions, or have a qualified electrician do the work.

Test the outlet once every month by pushing the TEST button; the REARRANGE button should pop out. If it does not, have the outlet serviced. To reactivate the outlet, press the REARRANGE button.

Choosing a wire with the appropriate gauge

- Utilizing an extension cord with the wrong gauge can cause a drop in line voltage, resulting in loss of power, excessive heat and tool

burnout.

- If, for instance, your tool has a 7 amp motor and you are utilizing a 75 foot extension cord, the minimum gauge should be 14.
- Select just round-jacketed extension cords listed by Underwriters Laboratory (UL).

Chapter 4 – Must have personal safety gear

The personal safety tools listed below can go a long way toward shielding you from most dangers in the workshop. But carrying an inventory of safety gear is not enough; the items must be appropriately used to protect you from injury.

The need for some items may not be readily apparent, while the dangers are very real. Few woodworkers need to be reminded of the cutting power of a spinning saw blade or jointer cutterhead.

Less well known are the long term effects of being exposed to the sound generated by power tools. We have also indicated the longest recommended time that an unprotected person can be exposed to various levels before risking permanent hearing loss.

Recall, too, that even short term exposure to some noise, while it may not lead to hearing loss, can dull the senses and cause a woodworker's alertness to flag-a setup for an accident.

Safety goggles

- Flexible, molded plastic goggles protect eyes.
- Type with perforated vent holes shields against impact injury and sawdust; type with baffled vents protects against chemical splashes, but non-vented goggles also obtainable.

Face shield

- Clear plastic shield protects against flying debris and splashes; features adjustable head gear.

Rubber gloves

- Household rubber gloves or disposable vinyl gloves protect against mild compounds or finishes; neoprene rubber gloves shield a skin from caustic finishing merchandises.

Ear muffs

- Cushioned muffs with adjustable plastic head strap protect hearing against high -intensity noise from power tools.

Work gloves

- For handling rough lumber, typically features leather or thick fabric palms and fingertips with elasticized or knitted wrists.

Safety glasses

- Standard plastic frames fitted with shatterproof lenses protect eyes from flying wood chips and other debris: typically feature side shields.

Dual cartridge respirator

- Protects against fumes when working with compounds or spraying a finish.
- Interchangeable filters and chemical cartridges shield against specific hazards; filter prevents inhalation of dust.
- Cartridges purify air and expel toxins through exhalation valve.

Ear plugs with neckband

- Detachable foam rubber plugs compressed and inserted into ear canals provide hearing protection from high-intensity power tool noise; plastic neckband fits around neck.

Reusable dust mask

- Features a neoprene rubber or soft plastic frame with an adjustable head strap and a replaceable cotton or fiber or gauze filter protects against dust and mist.

Disposable dust mask

- Fits over nose and mouth for one time use protection against inhalation of dust or mist features a cotton or fiber shield with an adjustable head strap and a metal nose clip.

While a ½ horsepower drill press is unlikely to damage your hearing-unless you run the machine all day long unprotected exposure to the noise developed by a 1 ½ horsepower router can be dangerous after just 30 minutes. Keep in mind that tools with dull cutters or blades generate more noise than those with well-sharpened cutting edges.

How to test a respirator for air leaks

- A respirator is just as good as its seal against your face.
- No seal, no protection.
- To test your respirator, place it over your face, setting the top strap over the crown of your head.
- Adjust the side straps for a snug fit.
- To test the respirator, cover the outlet valve with your hand and breathe out gently.
- There should be no air leakage around the face piece.
- If air leaks out of the respirator, readjust the straps for a tighter fit.
- Replace the face piece when necessary following the manufacturer's instructions, or replace the respirator.
- Use the appropriate filters for the job at hand.
- If you have a beard, use a full face mask with forced-air ventilation.

Chapter 5 – Must have first aid tools

Most woodworking accidents arise from the inappropriate use of tools and safety guards, unsafe work habits, and mishandling hazardous supplies. Take the time to set up appropriately for a job, gathering together the tools, tools, and supplies you need.

Always use the appropriate safety gear. Work technique; never hurry through a job. Be especially cautious or stop working if you are fatigued. Accidents can befall even the most cautious woodworker.

Board split, blades nick, and liquids splash. Numerous finishing merchandises comprise compounds that emit toxic fumes, causing dizziness or nausea. Keep in mind the potential hazards of any tool or material you use.

Store a first-aid kit, stocked with the basic supplies described below, in an simply accessible spot in your shop. In the event of an accident, you will want anyone to be able to find it rapidly to administer first aid.

Keep emergency telephone numbers handy. Techniques for handling some common shop mishaps are described on the following pages.

First aid supplies

- Adhesive bandages
- Tweezers
- Rubbing alcohol
- Hydrogen peroxide
- Gauze dressing
- Eye pads
- Eye irrigator
- Gauze roller bandage
- Medical tape
- Ipecac syrup

How to provide minor first aid

Clearing a particle from the eye

- Hold your affected eye open with the forefinger and thumb of one hand.
- Slowly rotate your eye, if necessary, to help expose the particle.
- Gently wipe away the particle utilizing the twisted end of a tissue moistened with water.
- Or, fill an eye irrigator with cool water and use it to flush out the particle.
- Lean forward with both eyes closed and press the rim of the irrigator against the affected eye, and tilt back your head.
- Open your eyes and blink several times to flush out the particle.
- If you cannot eliminate the particle, seek medical help immediately.
- Caution: Do not eliminate a particle that is on the cornea, is embedded, or has adhered to the eye.

Flushing a chemical from the eye

- Holding the eyelids of the affected eye apart, flush the eye thoroughly for at least 15 minutes under a gentle flow of cool water from a faucet or pitcher; tilt your head to one side to prevent the chemical from being washed into the uninjured eye.
- If you are outdoors, flush the eye utilizing a garden hose.
- Gently cover both eyes with eye pads or sterile gauze dressings and seek medical help immediately.

Pulling out a splinter

- Wash the skin around the splinter with soap and water.
- A metal splinter, even if you are able to eliminate it, may require treatment for tetanus; seek medical help.
- To eliminate the splinter, sterilize a needle and tweezers with rubbing alcohol.
- Ease the end of the splinter out from under the skin utilizing the needle, and then pull it out with the tweezers.
- Clean the skin again with soap and water.
- If the splinter cannot be eliminated, seek medical attention.

Treating a cut

- Wrap the wound in a clean cloth and apply direct pressure with your hand to stop any bleeding; keep the wound elevated.
- If the cloth becomes blood-soaked, wrap another cloth over it.
- If bleeding persists or the wound is deep or gaping, seek medical help.
- Otherwise, wash the wound with soap and water, then bandage it; for a narrow, shallow wound, draw its edges closed with a butterfly bandage.

How to control bleeding:

Applying direct pressure to stop bleeding

- To help stop profuse or rapid bleeding, apply direct pressure to the wound with a gauze dressing or a clean cloth and, if possible, elevate the injury.
- Direct pressure should stop the flow of blood and allow it to clot.
- If the dressing becomes blood-soaked, add another over the first one; avoid lifting the dressing to inspect the wound.
- It will be easier to maintain steady pressure if you wrap the wound with a roller bandage to add direct pressure.
- If you cannot stop the bleeding, call for medical help.

Treating a shock victim

- Some degree of shock-either immediate or delayed-accompanies any injury.
- Shock can be provoked by loss of blood, pain, or an allergic reaction.
- Signs of shock include anxiety or confusion; cold or clammy skin; weak, irregular breathing or pulse; and loss of consciousness.
- If you suspect an injury victim is suffering from shock, immediately call for emergency help.
- If the victim is conscious, place him on his back with his feet propped up 8 to 12 inches above the level of his head.

- Loosen the victim's clothing around the neck, chest, and waist.
- Keep the victim warm with a blanket, but avoid overheating.
- Do not give the victim anything to eat or drink.

Freeing a victim from a live current

- A person who contacts a live current may experience just a mild tingling sensation.
- Sometimes, nevertheless, the victim's muscles contract involuntarily around the source.
- Do not touch the victim or the electrical source.
- Instead, immediately stop the flow of electricity in the circuit at a wall switch or the service panel.
- If the electricity cannot be shut off immediately, use a dry wood implement, such as a broom handle, to knock the victim free of the electrical source.
- Call for medical help immediately, and then confirm the victim's breathing and pulse.
- If there is no breathing, give mouth-to-mouth resuscitation; if there is no pulse, give cardiopulmonary resuscitation (CPR) just if you are qualified.
- If the victim is breathing and has no neck or back injury, place him in the recovery position.
- Tilt the victim's head back face to draw his tongue away from his throat and keep the airway open. Keep the victim calm until help arrives.

Chapter 6 – Planning for basic shop layout

As they gain involvement and accumulate tools, most woodworkers pine for their own special place to practice their skills. In their fantasies, the workshop is an airy space equipped with a substantial workbench and an array of stationary machines and portable tools.

The reality for numerous woodworkers, nevertheless, is much more modest. The typical shop never seems to have enough light, power, or elbow room. Few homes have space precisely intended as a workshop area.

As a result, setting up a home shop demands creativity and flexibility; the task often involves converting an area initially intended for some other purpose. With cautious planning and forethought, Nevertheless, a location that might appear unsuitable can be turned into an efficient, comfortable place to work.

While size is often the first consideration, several other concerns may be more vital. For instance, situating a shop in a spare room on the main floor of a home may provide a large working area, but noise and dust from tools would perhaps inconvenience other members of the family.

To suit their own needs without intruding too much on the people they live with, woodworkers commonly locate home shops in the basement or a garage. Each has its pros and cons.

A basement is apt to be damp and may need to have its wiring and heating upgraded; access can be hampered by narrow doors, tight stairways, and low ceilings; and ventilation may be inadequate for finishing tasks.

A garage, on the other hand, is apt to be cold; it may require wiring and heating. The woodworker may end up jostling for space with a car or two. Still, with a bit of planning and the appropriate layout, even these locations can be turned to your advantage:

A basement can be heated and powered more simply than a garage. On the other hand, a garage has a larger door through which to move lumber and sheet supplies like plywood, its air is less humid, and the din of power tools and fumes of finishing can be isolated from living spaces.

The following chapters will outline some basic principles to follow when designing a new shop or upgrading an existing one. Topics include planning, allowing adequate space for tools; and providing for necessities like heat, light, and electrical power.

By listing your goals and closely examining your work, you can apply these principles to create a layout that suits your own needs.

It is far easier to shuffle paper cut outs of your tools on a template than it is to drag a table saw halfway across the shop. Time spent planning the layout of your shop will be more than amply rewarded in decreased frustration and increased efficiency when you go to work.

Designing a shop involves juggling numerous interdependent variables, from local humidity and the type of work you do to the height of the ceiling and the cost of wiring. To help sort them out, ask yourself a set of questions to help determine the kind of shop most suitable for your needs and remind you of factors that may affect its design.

Recall, too, a basic principle for any shop, that the lumber should take a rather straight path as it is processed almost as though the shop were an assembly line.

The best way to design the layout is to experiment with arranging photocopies of scale drawings of the tools on a sheet of graph paper. Recall that a tool should be situated so that an access door is visible from it.

In addition, a workpiece kicked back from the tool should not be able to strike someone working at another station. Consider dedicating spaces for specific woodworking tasks.

A finishing area or spray booth requires priority in planning because of light, temperature, and ventilation needs. Depending on the extent of your shop and local zoning and building codes, you may need to obtain permits; consult your local building inspection office.

Designing a shop around the woodworking procedure

- For maximum efficiency, lay out the tools in your shop so that the lumber follows a fairly direct route from rough stock to completed pieces.
- You will have to think about the entrance where lumber is stored on racks.
- Then the stock preparation area, devoted to the table saw (or radial arm saw), jointer, and planer; at this station, lumber is cut to rough length and surfaced.
- The heart of the then work area is the workbench.
- Radiating outward from the bench are the shop's other stationary tools, a drill press, lathe, router table (or shaper), and band saw.
- A tool cabinet should be nearby.
- Moving clockwise, the final work area should be set aside for assembly and finishing.

- This station should feature a table for gluing up pieces and shelves for drying and storing.
- The spray booth also should be close by, but isolated from the shop by walls on three sides.

Checklist for shop layout:

Location:

- Which obtainable areas in and around your home are appropriate for a shop?
- How easy is the access to these areas?
- Is the electric wiring adequate for powering your tools and lighting?
- How well are the areas heated, insulated, and ventilated?
- Will shop noise disturb other areas?
- If the location is a basement, will the shop be sharing space with a furnace room or laundry room?
- If the location is an outbuilding or garage, how much space is taken up by cars, bicycles, lawn mowers, and so on?
- Does the building or garage have any heating, electricity, or plumbing?
- How secure is the building or garage from theft?

Type of work:

- What type of woodworking ventures will you be doing?
- What size are the supplies you will need to move in and out of the shop?
- How much space will be devoted to storing lumber and work-in-progress?
- What stationary machines, portable power tools, and hand tools will you need?
- Are there enough electrical circuits to supply your power needs?
- How numerous lighting fixtures does your work require?
- How numerous workbenches, assembly tables, and accessories like tool cabinets, scrap bins, and sawhorses will you need?

- Will local seasonal temperatures and humidity affect your work?
- Will you be doing a lot of finishing work?

Work habits:

- What room temperature will you need to work comfortably?
- What type of light do you prefer for working?
- Will you be working while daylight hours, or will you be utilizing the shop at night?
- Which tools do you expect to use most often?
- Will you be working alone in the shop, or will it be used by another worker?
- Would that person have easy access to the shop?
- Will you need to lock the shop or keep it off-limits to children or pets?
- How numerous hours per day do you expect to spend in the shop?
- Is the flooring made of a material that is comfortable to stand on for long periods of time?

Setting up a shop in the garage

- The three stationary machines chosen are essential for most ventures: the table saw, the jointer, and the band saw.
- The saw and jointer are mounted on casters so they can be moved if necessary.
- With the bench and table there is ample space for hand tool and portable power tool work.
- The storage space perforated hardboard and shelving should be located along the walls; a lumber rack is situated near the garage door.
- Any exposed framing in the ceiling could also can be used to hold stock.
- Plan for the type and location, electrical outlets and light fixtures.
- You should also have a master switch near the bench's tail vise that controls all three machines.
- Attention should be also paid to feed direction of each machine,

the access door to the shop should be always in the user's field of vision.

- Caution: If your shop shares space with motorized tools you will not be able to spray finishes.

Setting up a shop in the attic

- Attic shops have several strikes against them:
- They are often not isolated and their floors are not intended to support heavy weight.
- In addition, headroom is limited and access can present issues, especially if you are working with long planks or full sheets of plywood.
- But for a luthier, carver, or woodworker who specializes in small ventures, an attic can be an ideal spot for a shop.
- Nailing sheets of sheathing-grade plywood to the joists will develop a floor that is sufficiently sturdy to hold up a workbench and one of the lighter stationary machines, like the band saw.
- The spaces between the studs and rafters and down near the eaves-where the roof and attic floor meet-are ideal for storing lumber, tools, and supplies.

Positioning stationary machines in a confined space

- If your workshop is cramped you may have to forego an ideal placement of stationary machines to allow you to make the most of your limited space.
- Consider the design of your machines and the feed direction you need to use; you may be able to place two machines close together if they are matched appropriately.
- The high table of a band saw and the feed direction typically used with the machine, For instance, makes it an ideal match in a tight space with a jointer.
- The two can be placed close together while still providing adequate space to operate each machine at separate times.

Setting up a basement shop

- The medium-size shop should share numerous of the features of the small shop: the table saw and jointer planer are on casters: a master switch but this time near the door that controls all the machines; the machines are situated so users will see the door near the bench; perforated hardboard and shelves for storage line the perimeter of the shop supplies can also be stored under the stairs; and the lumber rack is located near the main access door at the foot of the stairs.
- If you have the extra space, this shop should have room for a lathe, a drill press, and a dust collector.
- A work table for glue up and finishing should be situated at a window (if you have any) with an exhaust fan.
- The focal point of this shop is the table saw; it is equidistant from the stock preparation area in front of it, the workbench to one side, and the work table behind it.

Converting a two-car garage

- Setting up a shop with all the features mentioned so far calls for a large space, like a two car garage.
- This shop should have numerous of the characteristics of the smaller shops explained earlier, with supplementary tools and conveniences that allow it to handle a wider range of ventures.
- At one corner is a spacious finishing room, partitioned from the rest of the shop and equipped with an explosion-proof fan to exhaust fumes.
- The shop could also include a bathroom with a sink and a toilet.
- In addition to the machines featured earlier, this might have a radial arm saw, shaper, and planer.
- The shop should boasts three separate work exteriors: one in the finishing room, one for glue-up near the drill press, and a workbench beside the table saw.
- A shop of this size would need an independent electrical service panel to power all the tools.
- To keep the wiring out of the way, half the floor should be covered with a raised $\frac{3}{4}$ inch plywood floor; an under structure of 1 by 2s should laid on the concrete floor on 12 inch centers and

the plywood should be nailed to the boards.

- Wires should run in conduits under the plywood between the 1 by 2s.

Chapter 7 – How to plan electrical power layout

Electric power requirement should be considered early in the procedure of planning a shop's layout. Allow for growth. Then, as you add new tools and light fixtures, you will avoid the headaches of an inadequate system: repeated tripping of circuit breakers or blowing of fuses, and octopus adapters funneling several power cords into one outlet.

If you plan to wire your shop to your home's main service panel, be sure that your electrical supply has enough supplementary power. You can get a rough idea of how numerous amperes your shop will draw from the system by totalling the amperage of all the tools you plan to use and dividing the outcome in half.

If your system is barely able to handle the demands being placed on it by your household, you perhaps will need to upgrade your service entrance—in other words, increase the number of amps the service panel can draw from the utility company.

If the shop will be some distance from the main service panel, it is a good idea to install a 50-amp sub panel dedicated to the shop. Another point to Recall: Any woodworking machine that draws more than six amps should be on a separate (dedicated) circuit, unless the tool's motor is shielded.

As you plan, recall that even straightforward electrical jobs, like extending a circuit or replacing an outlet, can be dangerous. They can also cause a fair amount of damage, ranging from burned-out tool motors to a house fire if they are carried out inappropriately. Unless you are qualified and comfortable with the idea of wiring your shop to the electrical system, have a qualified electrician do the job.

TIPS:

- When planning the electrical layout for your shop, ensure that outlets for power tools and lighting fixtures are on separate circuits.
- Unless your shop has bright windows or your lights are equipped with battery backups, include at least two separate lighting circuits in your electrical layout.

- In the event one circuit is disabled, the lights plugged into the other circuit will still work.
- Place outlets close to the eventual location of the tools they will power; distribute outlets all around the shop to allow for future tool acquisitions.
- Avoid locating outlets on the floor; they will ultimately become filled with sawdust and be a fire hazard.
- Avoid plugging tools into one outlet utilizing an octopus adapter; this can overload your electrical system, and is a sign that the wiring of your shop is inadequate.
- Upgrade the system by installing new outlets and wiring them to a separate circuit on the service panel.
- Protect any new outlet in a garage or basement by installing a ground-fault circuit interrupter (GFCI).
- Never work on the wiring of the service panel; entrance wires may remain live even when power is shut off at the main circuit breaker or fuse block.
- Make certain that any new circuits or service sub-panels installed in your home or outbuilding are grounded to the main service panel.
- Individual outlets must also be grounded.
- Do not take off the cover of the service panel.
- Never work on your wiring in damp or wet conditions.
- Do not touch a metal faucet, pipe, appliance, or other object when working on your wiring.
- Never splice a power cord or an extension cord, or eliminate the grounding prong from a three-prong plug.
- Use an extension cord to supply electricity to an area just temporarily-not as permanent wiring.
- Never run a power cord or an extension cord under a rug, mat, or carpet; do not fasten the cord utilizing tacks, pins, or staples.
- Never replace a blown fuse with one of higher amperage; do not use a penny, a washer, or foil as a substitute for a fuse.
- If a circuit breaker trips or a fuse blows repeatedly, confirm for a short circuit, and determine whether the circuit is overloaded.

Tips for wiring the shop

- If the shop has six separate electrical circuits: four for tools and two for lighting, the basic principle is to keep in mind that no circuit utilizing 12-gauge wire should carry more than 80 percent of its capacity.
- For 20-amp circuits, this means the combined amperage of the tools on the same circuit plus 25 percent of the rating of the largest motor must not exceed 16 amps.
- In this scenario, the table saw and jointer should be on separate 240 V circuits; their power cords should be suspended from the ceiling with twist type outlets, which keep the plugs in place.
- With a combined load of 15 amps, the band saw and the drill press are on the same 120 V circuit; the lathe is on another.
- Supplementary outlets on the 120 V circuits can be used for portable tools.
- The incandescent and fluorescent lighting circuits are separate so that if one fails the other will still work.

Chapter 8 – How to plan appropriate lighting in your shop

If you find yourself cutting off line or cannot appropriately examine a finish unless you take your work outside, the lighting in your workshop may need an upgrade.

At best, a poorly lit shop will merely bring on fatigue; at worst, it can contribute to sloppy, imprecise work and to accidents. Fluorescent lights are the most popular type of workshop lighting fixture.

They cast a rather shadowless light, the tubes are long-lasting, and they use 20 percent to 30 percent less electricity than incandescent lights of the same brightness.

Numerous woodworkers find that too much fluorescent light can outcome in fatigue and headaches, Nevertheless, and prefer the warmth of incandescent and tungsten lights. At a minimum, a shop larger than 120 square feet needs 2 watts of incandescent light or $\frac{3}{4}$ watt of fluorescent light per square foot.

The shop lights should be circuits separate from your tools. Ideally, the light fixtures will be divided between two separate circuits. As a rule of thumb, do not exceed 1600 watts on one 20-amp circuit.

Also, distribute lighting fixtures around the shop; mounting a single fixture in the middle of the ceiling will make it hard to illuminate the shadowy areas at the edges of the shop.

If possible, make the most of natural light; there is no better substitute, especially for hand-tool work and finishing. Trying to evaluate planing, sanding, and finishing jobs under artificial light can be frustrating.

Both fluorescent and incandescent light tend to distort or disguise the exterior texture of natural and completed wood exteriors. Natural light, particularly from the north, has a soft, non-glare quality.

If your shop has a window that faces north, place your workbench under it. Keep in mind that upgrading the lighting in your shop need not entail purchasing expensive fixtures and rewiring the system. Simply painting a concrete floor a light color or covering the ceiling with white tiles will allow these exteriors to reflect light, rather than absorb it.

Chapter 9 – How to prepare the floors, walls and ceilings

Since most workshops are set up in basements or garages, concrete floors are a common feature. Yet for anyone who has to spend much time standing on concrete or sweeping it clean, the material can prove both uncomfortable and inconvenient.

The hard exterior is particularly tough on tools that are dropped accidentally. Simply painting a concrete floor with a paint made precisely for the purpose will keep down the dust and make the exterior easier to clean.

Adhesive vinyl floor tile can be laid down as well. Yet numerous woodworkers prefer the comfort of a raised wooden floor. A straightforward floor can be constructed from sheets of $\frac{3}{4}$ inch plywood laid atop a grid of 1 by 2s on 12 inch centers.

Not just is this type of floor easier on the feet, but wiring for stationary power tools can be routed underneath the raised exterior in $\frac{1}{2}$ inch plastic or steel conduit. Unlike the walls of most homes, those of separate workshops rarely are insulated.

If you live in a northern climate, you can increase the thermal efficiency of your shop by covering its walls with wood paneling or sheet material, and filling the gap in between studs with insulation.

Wood paneling in particular creates a warm, comfortable atmosphere. Interior wall covering will make your shop quieter too, since the walls will absorb some of the din of your power tools.

As a bonus, you can conceal wiring behind the walls. Ensure the basement walls do not leak before covering them with insulation and paneling. To hide the exposed joists, ducts, and wiring above your head, consider installing a ceiling.

A suspended tile ceiling, in which the tiles sit in a framework of supports hanging from the joists, is one popular option. In a large shop, a dropped ceiling such as this will also help retain heat. Acoustical ceiling tiles are an inexpensive alternative; the tiles are attached to furring strips that are nailed to the joists.

Chapter 10 – How to prepare the heating and ventilation

Heating is a necessity for most shops in the US. Some woodworking tasks demand it; gluing and finishing in particular require steady temperatures. Heating your shop also makes it more comfortable and safe; numb fingers invite accidents.

If your shop is some distance from your home's furnace, a separate heating system will be required. Numerous woodworkers swear by wood heat it has the added benefit of consuming scrap pieces.

Yet this means often feeding the stove and cleaning the chimney; insuring your shop against fire can also be an issue. Electric baseboard units are more convenient, but can contribute to high utility bills and often are clogged with sawdust.

Portable kerosene and propane burners should be avoided in the shop, since then use an open flame and emit toxic exhaust. Coil-type electric heaters are also a fire hazard. Whichever heating system you choose, keep the area around it free of sawdust and place it away from the finishing and wood storage areas.

And Recall, any system will be improved by good ventilation. Consider your need to control humidity. In shops in humid climates, too much moisture means an investment in a dehumidifier to keep wood dry and tools from rusting.

Shops in more arid climates face the opposite dilemma and may require a humidifier. Lastly, every shop requires adequate ventilation. Airborne sawdust and toxic finishing vapors may not be as visible a danger as kickback on a table saw but the threat they pose is just as real.

While fire or explosions due to high concentrations of sawdust or finishing vapors are rare, they can be devastating. A good ventilation system changes the air often enough to maintain safe levels of airborne dust and fumes.

It should include dust collection tools at each stationary power tool that develop sawdust, and a general exhaust setup to eliminate the dust and fumes that remain. While window fans or bathroom type vent models are fine for general exhaust functions, a finishing booth or spray room requires something different:

An explosion-proof tube-axial fan is recommended. Fans are rated by the amount of air that they move, measured in cubic feet per minute. Divide the cubic volume of your shop (its length times its width times its height) by 6 to find the rating required to change the air 10 times per hour-the minimum level for safe ventilation.

How to install a general exhaust setup

- If your shop does not have windows or doors to provide appropriate cross-ventilation, install an exhaust setup to clean the air.
- The system can be a straightforward one, consisting of an air intake at one end of the shop connected to the outdoors or your home's air ducts, and an explosion proof fan mounted in the wall at the opposite end.
- The intake is covered with a furnace or air-conditioning filter to clean the incoming air.
- The exhaust fan is placed higher than the intake, causing the air that rises to be drawn out of the shop.
- For best results, orient the exhaust setup along the longest axis of your shop.

Chapter 11 – How to prepare your workbench

The workbench is the curvestone of the woodshop, with a history almost as old as woodworking itself. Examples of primitive workbenches have been found dating back more than 2,000 years.

Woodworkers in ancient Rome advanced the basic design, devising benches with straightforward stops that allowed them to secure pieces of wood. Until that time, craftsmen were forced to hold their work, cutting or shaping it with one hand while chopping or planing with the other.

Further improvements came slowly, nevertheless, and vises were just added centuries later. With each refinement the workbench has assumed an increasingly indispensable role in the workshop. It is little surprise that numerous call the workbench the most vital tool a woodworker can own.

A good workbench does not take an active role in the woodworking procedure-it does not cut wood or shape it-but the bench and its accoutrements perform another essential task: They free your hands and position the work so you can cut, drill, shape, and finish efficiently.

In the past, even the most used benches have fallen short of the ideal. With its massive, single-plank top, the Roubo Bench of the 18th Century was popular throughout Europe, yet it had no tail vise or bench dogs to hold a workpiece; instead, the task was done by a system of iron holdfasts and an optional leg vise.

One hundred years later, the American Shakers improved on the Roubo. Their bench was a large affair that sported a laminated top, a system of bench dog holes, an L-fashioned tail vise, and a leg vise.

The Shaker bench was not too different from the modern cabinetmaker's bench. The design of the workbench has changed little since the early 19th Century; just its accessories and manner of assembly have been altered.

In fact, some claim that the just true innovation has been inventor Ron Hickman's ubiquitous Workmate. Advanced in the 1960s, the Workmate revolutionized the way numerous people look at work exteriors, because it provided some of the clamping abilities of a standard workbench with a collapsible, portable design.

While the Workmate has found a niche in workshops around the world,

numerous woodworkers-both amateur and occupational-still opt for nothing less than a solid maple or beech bench.

Often they select to build their own; believing that the care and attention paid in crafting such a bench will be reflected in their later work. The chapter that follows explains how to assemble a modern cabinetmaker's workbench, and how to install the vises and accessories required to turn an ordinary bench into a more flexible work station.

The workbench is patterned after a traditional cabinetmaker's bench, and is crafted from solid maple. The bench incorporates two vises considered to be standard tools a face vise on the front, left-hand end of the bench, and a tail vise with a sliding dog block mounted on the opposite end.

You can buy the plans for a bench and order the supplies yourself. Or, you can follow the instructions presented in this chapter and construct a bench to suit your needs.

Whichever route you take, a workbench is assembled in three distinct phases: the base; the top; and the clamping accessories-vises, bench dogs, and hold-downs.

The top exterior of most benches is generally between 33 and 36 inch high. The height that is best for you can be determined by measuring the distance between the floor and the inside of your wrist while you stand upright with your arms at your sides.

Finish your workbench with two coats of a penetrating oil based product, such as tung oil. Not just do these merchandises penetrate the exterior and protect the wood but the finish can be refurbished simply by scrubbing it with steel wool and recoating.

How to build the base

- The base of a workbench typically consists of two rectangular frames connected by a pair of stretchers.
- The frames are essentially identical, each with a foot, an arm, and two legs.
- The arm of the left-hand frame is sometimes about 3 inches longer than the other arm to provide supplementary support for the face

vise.

- For a bench, use 8/4 maple 1 ¾ inches thick after surfacing.
- The feet, arms and legs are made from two boards apiece face-glued together, and then decreased to the appropriate thickness on the jointer and planer.
- If you wish to build the base with mortise and tenons, cut four-shouldered tenons at the end of the legs and rout matching mortises in the feet and arms.
- Tenons are also cut at the ends of the stretchers with mortises required in the legs.
- The joints between the stretchers and the legs need to be solid, yet sufficiently flexible to be taken apart should you want to move the bench.
- Subsequently, knockdown hardware intended for the purpose is often used to join the stretchers to the legs.
- The pages that follow will detail some other techniques of reinforcing knockdown connections.

Utilizing truss rods

- Instead of utilizing mortise and tenon joints to build the base, use butt joints reinforced by truss rods.
- Obtainable in kits, the rods can be loosened or tightened after assembly to compensate for wood movement as an outcome of changes in humidity.
- Rout grooves for the rods into the edges of the stretchers and the inside edges of the legs; the depth and width of the channels should equal the rod's diameter.
- Test assemble the base and mark the groove locations on the legs and arms.
- Then bore a hole at each mark, making the diameter equal to that of the rods; countersink the holes so you can drive the nuts flush with the wood exterior.
- Assemble the base, fitting the rods into the grooves and holes, and tightening the connections with washers and nuts.
- Cover the grooves with solid wood inlay if you wish to conceal the rods.

Utilizing machine bolts and wood blocks

- To reinforce the connection between the legs and stretchers, glue a wood block of the same thickness as the stock to each edge of the stretchers.
- The blocks will increase the contact area between the stretchers and the legs.
- Once the glue is dry, cut a tenon at the end of each stretcher and a matching mortise in the leg.
- Fit the pieces together and bore two holes for machine bolts through the leg and the tenon in the blocks; countersink the holes.
- Make the connection fast by fitting the bolts into the holes, slipping on washers and tightening the nuts.

Utilizing lag screws and dowels

- Another way to strengthen a mortise and tenon joint between the stretchers and legs.
- Cut a 1 inch-diameter hardwood dowel to a length equal to the thickness of the stretcher.
- Then bore a 1 inch-diameter hole through the stretcher about 1 ½ inches from its end.
- Also bore a hole for a lag screw through the leg, stopping the drill when the bit reaches the hole in the stretcher; countersink the hole so the screw head will sit flush with the exterior.
- Fit the stretcher tenon into the leg mortise, tap the dowel into place in the stretcher, and drive the screw.
- Select a screw that is long enough to bite through the dowel.

How to prepare the feet

1 - Relieving the feet

- Once you are satisfied with the fit of the parts of the base, disassemble the stretchers and legs and relieve the feet on the jointer.

- Install a clamp on the jointer's infeed table to hold the guard out of the way while the operation.
- Set both the infeed and outfeed tables for a 1/16 inch depth of cut, and clamp stop blocks to both tables to guide the beginning and end of the cut.
- To make the first pass, lower the foot onto the knives, keeping it flush against the fence and the stop block on the infeed table.
- Feed the foot across the knives until it contacts the stop block on the outfeed table.
- Keep both hands well above the cutter head.
- Make as numerous passes as necessary to complete the recess, lowering the tables 1/16 inch at a time, and readjusting the stop blocks as necessary.

2 - Installing adjustable levelers

- To level a workbench on an uneven shop floor, install adjustable levelers in the feet.
- Each leveler consists of a T-nut and a threaded portion with a plastic tip.
- Bore two holes into the bottom of the foot near each end.
- Make the hole's diameter equal to that of the T-nut and its length slightly longer than the threaded section.
- Tap the T-nuts into the holes and screw in the levelers.
- Once the bench is assembled, adjust the levelers until the bench top is level.

How to build the top:

- One of the most vital features of a workbench is a perfectly flat top.
- At one time, a bench top could be built of solid maple or beech boards 12 inches wide and 2 inches thick.
- But today such planks are hard to come by, and bench top slabs are built up from narrow boards, layers of plywood sandwiched between strips of hardwood, or laminated plywood strips sheathed in hardboard.

- Nevertheless, edge gluing solid wood boards together butcherblock style is the timehonored technique.
- Cut from 8/4 stock, the boards are glued together first, then the slab is cut to length.
- To minimize warping, arrange the pieces so that the end grain is reversed.
- Also ensure that the face grain of all the boards runs in the same direction.
- This will make it easier to plane the top exterior of the slab smooth.
- After gluing up the slab, prepare the dog blocks.
- They are glued up from a length of 8/4 stock and one of 4/4 stock with the bench holes dadoed out of the denser board.
- The sliding dog block for the tail vise is sawn off before the front rail and fixed block are glued together.
- Then, the slab, fixed dog block, and rear rail are glued up; hardwood keys and plywood splines are used to strengthen the connections.
- After the sliding dog block, tool tray, and aprons are installed, the final step involves attaching the end caps to the top.
- Two connections are used:
- The cap are bolted to the slab and joined to the aprons by means of dovetail or finger joints.

Gutting the bench dog holes

- Bench dogs are fabricated from two boards, so it is straightforward to cut the dog holes in the denser piece before glue-up.
- Two steps are involved.
- First, cut a row of equally space dados wide enough to accept the dogs; angle the fixed-block dados slightly toward the tail vise, and the sliding-block dados away from the tail vise so that the dogs will grip the work firmly when clamping pressure is applied.
- Then, clamp the board to a work exterior and use a chisel to notch the top of each dado to accept the dog heads.
- That way, the dogs can be pushed down flush with the bench exterior when they are not in use.

- Now the two parts can be glued up to form the completed blocks.

How to assemble the bench top:

1 - Gluing up the top

- First, glue up the top slab.
- Before gluing up the bench top, rout grooves on both sides of the dog blocks and front rail, on one face of the front apron and back rail, and along the edges and ends of the top slab.
- Cut matching keys and splines.
- If you want to incorporate a tool tray in your bench, cut ½ inch rabbets into the bottom edges of the back rail and apron; later in the assembly procedure you will fit a piece of ½ inch plywood to form the tray.
- Set aside the sliding dog block with the hardwood keys glued in place and front and back aprons, spread glue on all mating exteriors, and clamp, alternating the bar or pipe clamps on the top and bottom of the work.

2 - Attaching the end caps

- The end caps can be applied while the tail vise is being installed.
- When that is done, invert the bench top and rout a T-fashioned recess at each end, centered between the edges.
- Cut two rectangular fittings from scrap hardwood so that they fit in the base of each recess.
- Notch one side of each fitting to accept a 3/8 inch nut, and place a fitting and nut in each recess.
- Set the end caps in position and mark where they contact the recesses.
- At each mark bore a hole for a 3/8 inch bolt, counter boring so the bolt heads are flush.
- Rout a groove in each end cap to accept the plywood spline, and rout a ½ inch rabbet on the bottom inside edge of the back rail to accept the tool tray.
- Install the tail vise on the right hand end cap.
- Spread glue on the contacting exteriors, fit the end caps, and bolt

them in place.

- Lastly, fit the front and rear aprons and tool tray and cramp.

Chapter 12 – How to prepare vises and accessories

Vises are the tools that transform the workbench from a straightforward, flat exterior into a versatile work station. The modern woodworking bench incorporates two types of vise: the face vise that secures work to the front edge of the bench, and the tail vise that uses wood or metal bench dogs to secure work on the top of the bench.

Face vises made exclusively of wood are rare. Nevertheless, a wooden vise is preferable to a metal type because wooden jaws can grip work without marring its exterior.

A good compromise can be reached by buying the hardware for a metal vise and mounting wooden face blocks. You can extend the capacity of a face vise by boring holes in the bench top and securing work between a bench dog in the vise's jaws and one inserted in one of the holes.

Tail vises are obtainable in two types: an enclosed model that incorporates a sliding dog block and one that features an L-fashioned block. Some tail vises extend across the entire end of a workbench and have two screws; these are known as end vises, and they extend the utility of an already versatile tool.

How to install a tail vise

1 - Installing the vise hardware

- To install a tail vise on a bench with a sliding dog block, position the vise collar against the right-hand side end cap and outline the hole for the vise screw.
- Then set a support board on the drill press table and clamp the end cap on top of it.
- Fit the drill press with a spade bit slightly larger than the vise screw and bore a hole through the end cap.
- Screw the vise collar to the end cap so the two holes line up.
- Then, secure the sliding dog block end-up in handscrews and clamp the handscrews to a work exterior.
- Position the vise flange on the block and mark its screw holes.
- Bore a pilot hole at each mark, and then screw the flange to the block.

2 - Assembling the vise

Fit the sliding dog block in the bench so the hardwood keys in the block run in the grooves in the sides of the rail.

Thread the vise screw through the vise collar, test fit the end cap on the bench top and lock the ball joint on the end of the screw into the vise flange.

Set the front apron in position against the dog blocks and test the movement of the vise by turning the screw.

If the sliding block binds, eliminate the end cap, apron, and sliding dog block, and ease the fit by paring the keys with a chisel.

Once you are satisfied with the vise's movement, attach the aprons, end caps, and trays.

How to install the face vise

1 - Preparing the face block

- Cut an 18 inch long $\frac{3}{4}$ by $3\frac{1}{2}$ inch hardwood support block and screw it in place under the front left corner of the bench, after boring a row of clearance holes for the bench dogs.
- Then, build up the face block by gluing two pieces of $\frac{8}{4}$ hardwood together; cut it to a final size of 5 by 18 inches.
- To mark and bore the holes for the vise screw and guide rods, mark a line across the face of the face block; offset the line from the top edge by the thickness of the bench top slab.
- Now use the carriage as a template:
- Center its top edge on the line and use a brad-point bit to accurately mark the position of the three holes and bore them.

2 - Preparing the bench

- Once the holes have been drilled through the face block, transfer their location to the workbench apron.
- Set the face block and bench top on sawhorses and use bar clamps to hold the block in position against the apron; protect the stock

with wood pads.

- Ensure that the top edge of the block is flush with the bench top and its end is flush with the end cap.
- Mark the hole locations on the apron utilizing the brad point bit.
- Eliminate the face block and bore the holes through the apron and bench dog block.

3 - Mounting the vise

- Attach the vise assembly, the faceplate, screw, and guide rods-to the face block.
- Turn the bench top upside down, place the vise carriage on the bench's underside, and feed the vise screw and guide rods through the holes in the apron and into the carriage.
- Make pilot holes on the underside of the bench and fasten the carriage in place.
- Then, fasten the guide rod bushings to the apron:
- Eliminate the vise assembly, fit the bushings on the rods, remount the assembly, and outline the bushings' location on the apron.
- Then eliminate the vise assembly again and secure the benchtop so the apron is facing up.
- With a router and straight bit, cut recesses for the bushings within the outlines.
- Screw the bushings to the recesses in the apron and attach the vise to the bench.
- Now the workbench top is ready to be attached to the base.
- Lay the top upside down on the floor, place the base in position, and drive lag screws through the arms into the top.

Fitting wooden inserts to metal jaws

- If your bench is equipped with a metal jawed vise, fitting interchangeable auxiliary jaws can extend the vise's versatility.
- The wooden inserts will not just be less damaging to work pieces than metal jaws, but they can also be custom-made for special jobs.
- Each insert is made from ½ inch-thick solid stock with a rabbeted

- 1-by-1 block glued at each end to hug the ends of the vise jaw.
- The basic jaw will do most standard clamping jobs.
- The tapered jaw features a wedge-fashioned strip for holding tapered stock efficiently.
- The V-groove jaw includes a strip with a groove cut down its middle for securing cylindrical work.

Utilizing a stepped block

- When securing a workpiece at one end of a face vise, the other end of the vise is likely to rack-or tilt toward the bench-and cause the work to slip.
- To prevent racking, use a stepped hardwood block to keep the jaws square.
- Cut a series of steps in one face of the block, spacing them at equal intervals, such as ½ inch.
- Place the block in the open end of the vise at the same time you are securing the workpiece so that the vise is parallel to the edge of the bench.

Sliding bench stop:

- If your "workbench" is a standard table with a bench vise fastened to one edge, the jig and fence can lend it some versatility.
- Cut the auxiliary vise jaws from 1 inch stock and the pieces of the T-fashioned vise jig from ¾ inch wood.
- You will need two pieces for the jig: a top and a lip.
- Rout a dado across one auxiliary jaw to accommodate the lip of the vise jig and another on the underside of the jig top.
- Screw the auxiliary jaws to the vise jaws, making a cut for the vise screw if necessary, then glue and screw the lip to the top of the jig.
- Cut the sliding fence from ½ inch thick stock and cut two stopped grooves through it for ¼ inch carriage bolts.
- To mount the fence, bore two holes through the table for the bolts, feed the bolts through the holes and the grooves and fasten them with washers and wing nuts.
- To use the jig and fence, slide the lip into the auxiliary jaw, adjust

the sliding fence to hold the workpiece snugly and clamp it in place by tightening the vise jaw and wing nuts.

Chapter 13 – How to prepare bench dogs and hold downs

Bench dogs are as vital as vises in maximizing the flexibility and utility of a well-intended workbench. A set of bench dogs works like a second pair of hands to secure workpieces for planing, chiseling, mortising, carving, or other woodworking tasks.

While the bench dog looks like a deceptively straightforward peg, it incorporates design features that enable it to hold a workpiece firmly without slipping in its hole. One feature typically is a thin metal spring attached to one side that presses against the inside wall of the dog hole in the workbench.

To help strengthen the grip of bench dogs, the holes are also angled toward the vise at 4 degree. Bench dogs can be either round or square. Round dogs are easier to incorporate in a bench that does not yet have dog holes; it is straightforward to bore holes than to make square dog holes.

Since round dogs can swivel, their notched, flat heads enable them to clamp stock in practically any direction. This can be a disadvantage: Some woodworkers claim that round dogs tend to slip in their holes more than square dogs, which cannot rotate.

Bench dogs can be made of either metal or wood. Metal dogs have a weight, strength, and stiffness that wooden ones cannot match. Yet wooden dogs have their advantages as any woodworker who has nicked a plane blade on a metal dog will attest.

Bench dogs are not the just technique of securing stock; bench hooks, carving hooks, wedges, and hold downs are also useful for keeping stock in place. The following pages will explain a number of commercial and shop-made options to keep workpieces put while you work.

Making a wooden bench dog

- Bench dogs can be crafted from hardwood stock; uses an angled wooden tongue as a spring.
- Cut the dog to fit the holes in your workbench, then chisel out a dado from the middle of the dog.
- Saw a short kerf into the lower corner of the dado, angling the cut so the tongue will extend beyond the edge of the dado,

- Cut the tongue from hardwood, making it about as long as the dado, as wide as the dog, and as thick as the kerf.
- Glue the tongue in the kerf.

Making a spring-loaded bench dog

- A wooden bench dog can be made to fit snugly by equipping it with a metal spring cut from an old band saw or hacksaw blade.
- Cut your dog to size, and then chisel out a small recess for the spring.
- The width and depth of the recess should equal the width and thickness of the spring, but its length should be slightly shorter than that of the spring.
- Press the spring into the recess; the metal will bow outward, holding the dog firmly in its hole.

Making and setting up carving dogs

- Utilizing a standard bench dog as a model, you can fashion a pair of customized dogs that will grip a carved or turned workpiece, or secure irregular-sized work, such as mitered molding.
- To make these accessories, cut bevels on either side of the head of a standard bench dog and drive a small screw or nail into the center of the head; snip off the fastener's head to form a sharp point.
- To use the devices, place one dog in a dog hole of the bench's fixed dog block and the other in the tail vise or a sliding dog block hole.
- Tighten the vise screw until the points contact the ends of the workpiece and hold it securely.

How to build a shop made edge dogs

- Edge dogs are ideal for securing a workpiece along the edge of your bench.
- They feature a round dowel at one end that drops into a bench dog hole and angled heads that butt up against the edge of the bench

and hold the work.

- Start by cutting the dogs from hardwood stock.
- Both left-hand and right-hand dogs are required, with the heads angled in opposing directions.
- Bore a $\frac{1}{2}$ inch-diameter hole through the ends, and drive a 3-inch length of dowel in each hole.
- Then insert the dowel in a bench dog hole and angle the dog so it extends beyond the edge of the table.
- Mark a 90 degree notch for the head perpendicular to the edge of the bench and cut it out.
- To hold the edge dog in place when clamping pressure is applied, saw a $\frac{1}{4}$ inch-slice off the bottom of the dog, except for the head.
- This provides a lip that will butt against the edge of the bench.
- To use the edge dogs, place the left-hand dog in a hole in the fixed dog block and the right-hand one in the sliding dog block of the tail vise.
- Tighten the vise until the workpiece is held in the notches.

Utilizing a hold-down clamp

- Commercial hold-down clamps can be used alone or with bench dogs to secure a workpiece in place anywhere on a workbench.
- These feature an adjustable holding bolt which sits in a counter bored hole through the bench top.
- To use the clamp, raise the bolt head and slide it through the notch at the base of the clamp.
- Set the workpiece under the clamp jaw and tighten the screw.
- To eliminate the clamp from the bench, slide it off the bolt head and let the bolt drop below the exterior of the top.

Making and utilizing a temporary bench stop

- A clamped-on bench stop cut from $\frac{3}{4}$ inch plywood will secure a workpiece to the bench top without the help of bench dogs.
- Cut the bench stop to size, then mark out a triangular wedge, typically 3 inches shorter than the stop.
- Cut out the wedge and set it aside.

- To use the bench stop, clamp it to the bench top and slide the workpiece into the notch, butting one side against the straight edge of the notch.
- Secure the piece with the wedge, tapping it firmly in place with a mallet.

Installing a wedge stop

- A wedge stop can also be used to secure stock on a bench top.
- The stop consists of a fixed rail and a movable rail that are secured by dowels resting in a double row of holes bored into the workbench.
- Together with a triangular wedge, the rails keep a workpiece from moving.
- Cut the rails and the wedge from $\frac{3}{4}$ inch plywood.
- You can select denser stock for the rails, depending on the thickness of your workpiece.
- Bore two $\frac{1}{2}$ inch diameter holes in each rail, and then glue a 2-inch-long dowel in each hole.
- Bore two rows of $\frac{1}{2}$ inch-diameter holes in the workbench for the dowels.
- To use the stop, place the fixed rail at one end of the row of holes and the movable rail the appropriate distance away so the wedge, when situated between the rails, will keep the workpiece steady.

Making a bench hook

- The shop-built jig will ensure that the crosscuts you make on the workbench will be square.
- Use $\frac{3}{4}$ inch plywood for the base and strips of 2 by 2 stock for the lips.
- Make the base at least as long as the width of your workpiece and wide enough to support it.
- Screw the lips to the guide, attaching one to each face.
- To use the jig, butt one lip against the edge of the bench and press the workpiece firmly against the other.
- Align the cutting line with the edge of the base and make the cut.

Making a flip-up stop

- The flip-up bench stop provides another way to make quick guided crosscuts on a workbench.
- Cut the two pieces of the stop from hardwood.
- Screw the pieces to the end of the benchtop; on the bench, the inner edge of the pivoting piece is lined up with the edge of the tool tray to provide a convenient reference line for squaring up a crosscut.
- Screw the stationary piece in place with two screws, and the flip-up piece with one so that it can pivot.
- When not in use, the pivoting piece should lie on edge atop the stationary piece.
- To use the stop, flip up the pivoting piece, butt the workpiece against it, and make your crosscut.

Making and utilizing a miter bench hook

- Customize a standard bench hook to make 45 degree angle miter cuts by adding kerfs to one of the lips.
- Build a bench hook, and then use a backsaw to cut two kerfs in the lip at opposing 45 degree angles and one at 90 degree).
- Use the miter bench hook as you would a standard bench hook, lining up the cutting line on the workpiece with the desired kerf.

Chapter 14 – Must have supplementary shop accessories

Look beneath the exterior of an efficient, well equipped shop, and you will find several invisible accessories intended to make the work safer and the shop more comfortable in which to work.

The most commonly found helpers are compressor generators, bench grinders, and perhaps the most vital for safety and comfort are dust collector systems.

Air compressors first were utilised by woodworkers just for finishing work to apply lacquer and varnish more smoothly than with the brush. But with the advent of such tools as compressors are found more often, even in small home workshops.

Generators too, are finding a place, especially among those woodworkers who take their craft away from home and power lines. Grinders can speed tool sharpening. More vitally, they can permit you to modify tools and reclaim damaged cutting edges.

Airborne dust once was considered an unavoidable consequence of working with wood. But the increased emphasis on environmental health has led to the introduction of efficient dust collection systems that are affordable to home woodworkers.

They should be a high priority item for every home workshop. Tiny wood dust particles can remain in the shop for more than an hour after a tool has been used.

The dust poses several health risks. If the wood contained toxins or irritants, and numerous species do, the effects can lead to a wide range of ailments, including dermatitis, shortness of breath and dizziness.

Recent studies have shown that long term inhalation of wood dust is at least a contributing factor in cancer of tongue, lung, and larynx. When you add to the equation the fire risk and the hazard of the dust covered shop floor, there are compelling reasons for installing some kind of dust collection system in your shop.

Recall that designing a central system requires cautious attention to detail and precise calculation of your specific requirements. To be safe, confirm your plans and figures with an engineer before installing the system.

Shop accessory item examples:

- Multitester
- Air compressor
- High-volume, low-pressure (HVLP) spray system
- Generator
- Shop vacuum
- Bench grinder
- Wheel dresser

Chapter 15 – Air compressor tips

An air compressor can be fitted with a large number of tools and attachments, making it a convenient shop accessory. In some shops, a compressor can represent an alternative to some electric tools. For others, it can be a valuable supplement.

Pneumatic drills, grinders, sanders, and wrenches perform at least as effectively as their electric-powered counterparts. Some tools, like sprayers, nailers, and abrasive cleaners, are clearly superior to the alternatives.

Compressors and the tools they drive are inherently straightforward: The air is drawn in, pressurized by a diaphragm or one or more pistons, and typically stored in a tank.

When the trigger on an air-driven tool is pressed, the air travels through a hose to power the tool. Because they comprise no heavy electric motor, most air tools are lighter, cheaper, and easier to repair than their cousins.

They cannot overheat, and there is no danger of electrical shock. Compressed-air power does have some drawbacks, chiefly the cost of the compressor itself and maintenance. Air drills and the like must be oiled daily.

And you will invest several hundred dollars in a compressor that is capable of driving typical shop tools. Some air-powered tools require a sizable volume of air, typically measured in cubic feet per minute; others need a minimum level of air pressure in pounds per square inch.

When choosing a compressor, consider the cfm or psi requirements of the air-powered tools you plan to use and buy a compressor with slightly more power. You never know when you will want to expand your tool inventory.

COMPRESSOR SAFETY TIPS:

- Read your owner's manual cautiously before operating a compressor or any air-powered tool.
- Do not rearrange any switches or valves on the compressor; they have been prearranged at safe levels at the factory.
- Confirm the hoses, plugs, wires, pipes, and tubes of the compressor, and the tool air inlets before each use.
- Do not use the compressor or tool if any part is worn or damaged.

- Wear safety glasses and hearing protection when utilizing air-powered tools.
- Do not exceed the pressure rating of an air tool or accessory.
- Always plug a compressor into a grounded outlet of the appropriate amperage.
- Relieve pressure slowly when depressurizing the tank.
- Do not press the trigger of an air tool when connecting it to an air hose.
- Do not eliminate the belt guard of a belt driven compressor when the machine is operating.
- Turn the compressor off if it develops an unaware noise or vibration, develops insufficient air pressure, or consumes excessive oil; have the machine serviced before resuming operation
- Allow the compressor to cool before performing any maintenance; wear gloves to disconnect any parts that are still hot.
- Turn the compressor off before moving it.
- Do not touch the compressor while utilizing it or immediately after; the machine can become very hot.
- Drain any moisture from the tank after each use to prevent rust; tank pressure should be no higher than 10 psi when draining it.
- Replace the tank if it has any pin holes, rust spots, or weak spots at welds.

Chapter 16 – Portable Generator tips

The regular home and shop is so well equipped with electric fixtures, outlets, and extension cords that it is easy to take for granted the essential role that electricity plays in our lives. Yet a power outage can rapidly remind you of that role.

At such a time, a portable AC generator becomes an indispensable accessory for your home, your shop, or in a remote cabin where power lines do not reach. AC, or alternating current generators typically feature a gasoline motor that drives an alternator.

Models are obtainable with motors ranging from 3 to 8 horsepower, producing 500 to 4000 watts of power. There are several factors to consider when selecting a generator. The generator must develop enough power to start and run the tools and any other electrical devices you plug into it.

You should refer to the actual rating of your tool, which is typically printed on the tool body. If not, you can calculate the rating by multiplying the tool's amperage rating by the voltage.

For instance, a 3-amp tool operating on 120 volts would have a wattage rating of 360. The wattage rating of a generator refers to its continuous running wattage.

While all models feature a surge or maximum rating as much as 25 percent higher than the running value, you should rely on the running wattage rating when choosing a generator.

A generator with more power than you need will run more smoothly for longer stretches and require less maintenance. Most generators are equipped with one to four 120-volt outlets. Numerous models also have a 240-volt outlet and a 12-volt DC output for charging batteries.

Ensure that any generator you buy is equipped with an effective muffler. Also confirm the size of the fuel tank. The generator should be able to run for at least 90 minutes on a full tank.

Choosing a generator with a suitable wattage rating

- All electric tools require more power to start up than for continuous running.

- When selecting a generator, ensure that its wattage rating is higher than the start-up wattage of your most powerful tool.
- Add a safety margin of about 20 percent to the combined running wattage of all tools you will plug into the device and operate at the same time.

GENERATOR SAFETY TIPS:

- Read your owner's manual cautiously before operating a generator.
- Never run a generator indoors; like any internal combustion engine, it develops carbon monoxide fumes that are deadly in a confined space.
- Do not fill the generator's fuel tank while the motor is running or hot.
- Add fuel to the fuel tank at least 10 feet from your work area and any sources of heat or flames.
- Do not fill the tank right to the brim; the fuel can expand and overflow.
- Do not smoke while filling the fuel tank.
- Clean up any gas or oil spills immediately, wiping up the area with a clean cloth, or soaking it up with an absorbent material such as cat litter or vermiculite; avoid utilizing sawdust, which is combustible.
- Place fuel-soaked rags in sealed metal containers and dispose of them following local environmental regulations.
- Do not eliminate any safety guards, covers, or screens from the generator while the machine is operating.
- Keep gas and oil just in containers intended precisely for fuel storage and clearly marked FUEL.
- Keep the containers away from sources of heat and flames.
- Confirm the engine oil level each time you refuel the generator.
- Confirm the generator's fuel lines and connections regularly; if you notice any leakage, turn the machine off and have it serviced before resuming operations.
- Never use a generator with a faulty or damaged exhaust system.
- Ground the generator following the manufacturer's instructions; this will divert any stray current from a short circuit to ground,

reducing the risk of electrical shock.

- Do not connect a 240-volt tool or appliance to a 120-volt receptacle.
- Do not overload the generator by plugging in power tools or appliances with higher wattage ratings than that of the generator.
- Never wire the generator to the electrical system of your home or shop in an attempt to provide power while an outage.
- This practice, known as "backfeeding," is unlawful in some areas, as it poses a risk to anyone working on the electrical system.
- Keep your hands and face away from carburetor whenever the air cleaner has been eliminated; a sudden backfire, or explosion of fuel in an engine cylinder can cause serious burns.
- Do not touch the generator engine or exhaust piping while the machine is running or immediately after turning it off; these parts can become very hot.
- Allow the generator to cool before performing any maintenance.
- Turn the generator off before performing any maintenance on it; also disconnect the spark plug wire and the battery to prevent accidental start up of the motor.
- Generator use is regulated by federal and state legislation in some areas; contact the appropriate authorities in your community for any applicable laws.

Chapter 17 – Bench Grinder tips

From dressing and shaping metal to squaring and sharpening bits, plane irons, and chisel blades, the bench grinder is an invaluable workshop maintenance tool. Grinders are classified according to their wheel diameter.

The 5 to 7 inch bench top models, with $\frac{1}{4}$ to $\frac{1}{2}$ horsepower motors, are the most popular home workshop sizes. They can be mounted on a work exterior or fastened to a separate stand.

Grinding wheels come in numerous grits and compositions. Medium 36 and 60 grit aluminum oxide wheels will handle most tasks adequately, but you may need a finer wheel, with either 100 or 120 grit, for delicate sharpening jobs.

Buffing wheels for polishing metal, and wire wheels for removing rust and cleaning metal, are also worth owning. Most grinders operate at one speed, or allow a choice of two speeds typically 2950 and 3600 rpm.

Some newer models offer variable speeds, a particularly valuable option for polishing and cleaning and for grinding with speeds low enough to maintain the temper of a steel tool.

No grinder should be used without lowering the guard mounted above each wheel; the tool should also come equipped with adjustable tool rests and wheel covers sheathing 75 percent to 80 percent of the wheels.

More expensive grinders may have other features, such as spark arresters, a water tray for cooling tool tips, and exhaust outlets. Confirm your grinder wheels regularly for fractures and, as the wheel wears, adjust the distance between the tool rest and the grinding wheel to about $\frac{1}{4}$ inch.

A grinding wheel will ultimately become dull and clogged with metal particles, and its edges may go out of square. A wheel dresser is a special tool that is used to true the working face of a grinding wheel and square its edges.

Truing the wheel

- To true a grinder wheel and square its edges, use a star wheel dresser or a diamond-point dresser.
- For the star-wheel dresser, move the grinder's tool rest away from

the wheel.

- With the guard in position, switch on the grinder and butt the tip of the dresser against the wheel.
- Then, with your index finger resting against the tool rest, move the dresser side-to-side across the wheel.
- For the diamond point dresser, hold the device between the index finger and thumb of one hand, set it on the tool rest, and advance it toward the wheel until your index finger contacts the tool rest.
- Slide the tip of the dresser across the wheel, pressing lightly while keeping your finger on the tool rest.
- For either dresser, continue until the edges of the wheel are square and you have exposed fresh abrasive.

Gouge sharpening jig

A jig guarantees that the tip of a gouge will contact the wheel of your grinder at the correct angle to restore the bevel on the cutting edge.

The dimensions provided will accommodate most gouges.

Cut the base and the guide from $\frac{1}{2}$ inch plywood.

Screw the guide together and fasten it to the base with screws countersunk from underneath.

Ensure that the opening created by the guide is large enough to allow the arm to slide through freely.

Cut the arm from 1 by 2 stock and the tool support from $\frac{1}{2}$ inch plywood.

Screw the two parts of the tool support together, then fasten the bottom to the arm, flush with one end.

For the V block, cut a small wood block to size and saw a 90 degree wedge out of one side.

Glue the block to the tool support.

- To use the jig, secure it to a work exterior so the arm lines up directly under the grinding wheel.
- Seat the gouge handle in the V block and slide the arm so the beveled edge of the gouge sits flat on the grinding wheel.

- Clamp the arm in place.
- Then, with the gouge clear of the wheel, switch on the grinder and reposition the tool in the jig.
- Holding the gouge with both hands, rotate it from side to side so the beveled edge runs across the wheel.
- Confirm the cutting edge periodically and stop grinding when the bevel forms.

Chapter 18 – Dust collection tips

A dust collection system has one aim: to capture most of the wood dust created at each of your woodworking machines and prevent it from ending up on the shop floor, or, worse yet, in the air.

There are a series of variables in every system that must be coordinated to ensure a robust enough flow of air: the power of the collector; the location and requirements of the machines in the shop; and the type, size, and layout of the duct work.

The design of a central system begins with a straightforward bird's-eye view sketch of your shop, arranging the machines and collector in their favoured locations.

Then, draw in a main line running from the collector through the shop. Sketch in branch lines as required to accommodate each machine and any obstructions-joists, beams, or fixtures-that may require special routing.

For the best air flow, keep the main line and branch lines as short and straight as possible, and position the machines that develop the most dust closest to the collector.

You may select to run ducting along the ceiling of the shop, or, to increase the efficiency of the system, at machine table height along the walls. Since in most home shops just one woodworking machine will be producing dust at a time, 4 or 5 inch-diameter duct is sufficient for both the main and branch lines.

There are several suitable types of duct obtainable for dust collection systems. The best choice is metal duct intended precisely for dust collection. Nevertheless, numerous woodworkers opt for plastic pipe, typically PVC or ABS.

It is easier to seal and assemble, and disassemble for cleaning, less expensive, and more readily obtainable. Because plastic is an insulator, Nevertheless, static build-up inside the pipe can reach dangerous levels while use-possibly high enough to ignite the dust passing through it.

To prevent this, ground all plastic ducts by running a bare copper ground wire from each tool, inside the duct, to an electrical ground. As a safety precaution, have the system checked by an electrician. Smooth-wall rubber

hose and flexible plastic hose, often used as branch ducts to connect machines to the main line, are other duct options for the home shop.

Most of these merchandises also require electrical grounding. A central dust collection system requires a selection of fittings to route and join lengths of duct and dust hoods.

If you run the main line along the ceiling, you can secure it in place with wire straps nailed to furring strips mounted between the joists. Fittings directly affect the efficiency of the system, so select them cautiously. As a rule, gentle curves are better than sharp turns, so use Y fittings instead of Ts for branch connections, wherever possible.

A blast gate should be located at each branch outlet to seal ducts when they are not being used, thereby increasing air flow to the machine in use. Hoods, whether commercially made or shop-built, should be situated as close as possible to the source of the dust.

You have a choice of techniques for connecting ductwork. Numerous ducts and fittings can be friction fit and secured with adjustable hose clamps. Duct tape can also effectively join plastic pipe, but it is unsightly and will decay over time.

A high-quality silicone sealant is perhaps a better choice for a permanent system. To ensure smooth air flow metal ducts should be joined with rivets, rather than screws or bolts.

Once you have completed the layout of your system and selected the type of duct you will use, it is time to calculate your dust collection needs and select a collector. This involves determining the requirements of the heaviest dust collection task your system must handle.

This typically will be the sum of system losses and the air volume demanded by the machine most distant from the collector. Purchase a collector with slightly more capacity. System losses are caused by such inefficiencies as bends in the line, corrugated ducting, leaks, and hoods without flanges.

Choosing between single and two-stage collectors

- Two basic types of dust collectors are obtainable for home workshops: single- and two stage machines.

- In single-stage collectors, debris and dust laden air is drawn through an impeller, where cyclone action deposits heavy dust and debris into the waste container below while the lighter dust rises to the dust bag.
- Single-stage collectors are rather loud and the dust and debris tend to wear out the bag and impeller rapidly.
- In two-stage collectors, the impeller is located above the inlet duct so the heavier particles drop into the waste container before any air passes through the impeller and bag.
- This is quieter, and decreases wear on the impeller and dust bag.
- Two-stage collectors are rather harder to clean.

Connecting a dust collection system to tools with dust ports

- Use a commercial adapter to attach a collection hose to a machine dust port.
- The adapter should be sized to friction fit with the collection hose at one end and slip over the dust port at the other.
- For the radial arm saw, a hose clamp is used for reinforcement.

Hooking a planer up to the system

- A hood can be custom built to capture most of the dust generated by your planer.
- Make the hood from galvanized sheet metal, cutting the pieces with tin snips.
- Leave tabs where the pieces overlap so they can be pop riveted together.
- Make flanges on the sides to improve the seal and a hole in the back for the dust collection hose; you will also need to create a lip along the top to connect to the ledge of the planer's chip discharge chute.
- Use an adapter to join the hood to the hose, inserting one end in the hole in the hood and the other end in the hose; reinforce the connection with a hose clamp.
- Fasten the lip of the hood to the planer with sheet metal screws.

Connecting a collection hood to a router table

- A hood attached to the fence of a router table will collect most of the dust developed by the tool.
- Cut the hood from $\frac{1}{2}$ inch plywood, sizing it so the sides hug the outside edges of the fence's support brackets.
- The bottom edge of the back flange should rest on the table; the top flange should sit on the top edge of the fence.
- Before assembling the pieces of the hood, cut a hole through the back for the collection hose.
- Also bore holes for screws through the sides and screw angle irons to the back so that their inside edges are flush with the opening for the hose.
- Screw the hood together, and then fit the collection hose in the back.
- Use a hose clamp to secure the hose to the angle irons and position the hood on the fence.
- Screw the sides of the hood to the fence brackets.

Setting up a shop-made sanding station

- To decrease the amount of dust generated by power sanding, build a portable stall that fits on a table or workbench.
- Cut the back, top, and sides from $\frac{1}{2}$ or $\frac{3}{4}$ inch plywood.
- Taper the top edges of the sides to create a comfortable, open working space.
- Cut an outlet in the back of the station for a dust collection hose or branch duct.
- Assemble the station with screws.
- Position the sanding station securely on your work exterior; attach the collector hose to the outlet.
- Turn on the collector before you begin a sanding operation.

Chapter 19 – Portable dust collection tips

A central dust collection system may sound like overkill to the craftsman with a small home shop. While such systems are generally more efficient than independent collectors, they can be costly and consume considerable space.

If your shop area is restricted, and just one machine will be operated at a time, consider a portable dust collector. Numerous types of portable dust collectors are obtainable.

Most are robust enough to power a central system, yet light enough to be toted around the shop. If you are planning to set up a portable collection system, shop around for the most transportable collector that can handle your needs.

Keep in mind that you may want to expand to a central system later. Numerous home woodworkers will find that a shop vacuum, While not ideal, can do a satisfactory job most of the time if you are willing to work around the drawbacks.

Shop vacuums are intended to move a small volume of air at high velocity through a small-diameter hose. Dust collectors, on the other hand, move a large amount of air at a lower speed. A shop vacuum dust hood, therefore, should be situated very close to the tool.

Larger chips will tend to clog vacuum hoses, requiring frequent cleaning. And, vacuums powered by universal motors tend to wear out rapidly. Models with induction type electric motors will last longer, but cost more than a portable dust collector of the same Dower.

If there is no dust collection system portable or central in your shop, try the techniques described on the following pages to control airborne dust. These techniques are also effective supplements to collectors that suck up a majority of shop dust, but still leave some particles floating in the air.

How to expand a dust collector's capacity

- You can more than double the capacity of your portable dust collector or shop vacuum by attaching a 55 gallon drum or a large plastic barrel as a mid-stage collector.

- Install plastic intake and exhaust ports on the drum and mount a hose to the intake port on the drum to collect wood dust and chips.
- The 90 degree elbow on the intake port will create a cyclone effect inside the barrel, forcing chips and heavier sawdust against the walls of the barrel.
- Lighter dust will be drawn through the exhaust port into the shop vacuum or dust collector.
- For easy assembly and disassembly, use pipe fittings that form a friction fit with the hose from your vacuum or collector.

How to set up positive-pressure ventilation

- To maintain clear air in a shop when you are generating a great deal of airborne dust or chemical fumes, set up a positive-pressure ventilation (PPV) system.
- Open all the windows in the shop and position a fan outside the door so that the airflow it develops will envelop the doorway.
- The stream of air will follow the path of least resistance-through the door and shop, and out the windows, clearing airborne dust and fumes rapidly.
- PPV has some limitations, nevertheless.
- The system will just function appropriately if the window openings are large enough to handle a sufficient volume of air.
- Also, the rest of your home must be well sealed off from the shop.
- A more permanent alternative to PPV can be fashioned by mounting an explosion-proof exhaust fan in a shop window.
- Set up to pull air out of the room, the fan will create negative pressure, expelling fumes and dust in larger volumes than is possible with PPV.

Filtering shop air

- Another quick and easy technique of ridding the shop of airborne dust uses a furnace filter on the back of a portable room fan.
- When the fan is turned on, suction will hold the filter in place and draw dust out of the air.
- The dust will remain on the filter, which can then be brushed off

outside or vacuumed.

Chapter 20 – How to store wood

Appropriately stored lumber and plywood are not just kept out of the way but straight and dry, too. For most shops, this involves storing lumber in racks that hold the wood off the floor.

Wood shrinks and expands according to the amount of humidity to which it is exposed. A wet floor can warp lumber and delaminate some plywoods. The lumber racks featured in this section are easy and inexpensive to build; you should be able to find a suitable design and adapt it to your needs.

If you have the space, you can set up an end loading lumber rack. Such a system is rather easy to construct but you will need a wall twice the length of your lumber to allow for loading and unloading.

If space in your shop is at a premium, consider a front-loading rack. If versatility is required, get a rack that allows you to store boards both horizontally and vertically.

Avoid utilizing Z-fashioned brackets; they waste too much space. The typical shop can stock hundreds of pounds of lumber so it is crucial to anchor your rack firmly-to at least every second wall stud or floor joist.

Make the most of spaces that you would not ordinarily consider as prime storage areas. If your ceiling is uncompleted, nail furring strips across the joists for handy shelving to store short stock and dowels.

Storing planks and boards

- The storage rack at right features vertical supports screwed to wall studs.
- Cut from 2 by 4 stock, the supports buttress shop made wood brackets, which hold up the lumber.
- You will need one support at each end of the rack, with an supplementary one every 32 inches along the wall.
- After bolting the support to the studs, prepare the brackets by cutting the sides from $\frac{3}{4}$ inch plywood and the middle shelf piece from 2 by 4 stock 1 $\frac{1}{2}$ inches shorter than the brackets.
- Angle the top edge of the sides by about 5 degree so the brackets will tilt up slightly and prevent the lumber from falling off the

rack.

- Screw the middle shelf piece to the sides, and then screw the bracket to the vertical support.

Lumber and plywood rack

- Intended to accommodate both boards and plywood panels, the rack described rests on the shop floor and attaches to joists in the ceiling.
- Lumber is loaded onto the rails from the end, while plywood can be stacked in the trough at the front and held in place by the hinged bar.
- To build the rack, first cut the rails and stiles from 2 by 4 stock, and then notch them together:
- Starting 24 inches from the bottom end of the stiles, cut a series of 3 ½ inch-wide, 1 ½ inch-deep dados every 24 inches.
- Cut rabbets at both ends of each rail to match the dados in the stiles.
- Screw the rails and stiles together, and then bolt the top ends of the stiles to every third joist, making them 48 inches apart.
- Once the grid is fixed to the ceiling joists, screw the crossbars to the front stiles, centering them between the rails.
- Assemble the plywood trough with screws before fastening it to the bottom of the front stiles.
- Lastly, attach the hinged bar to the trough lip with a butt hinge, and cut two notches in the free end of the bar for a looped cord to hold the bar upright.

Building an adjustable pipe rack

- The rack described is made of 4 by 4 stock and steel pipe, is attached to wall studs.
- The steel pipes should be roughly 24 inches long and ¾ inch in diameter.
- They can be inserted into any of the holes drilled into the vertical supports or crosspieces, allowing lumber to be piled on the pipes or stacked on end between them.

- Begin by cutting the uprights to length and mark each point on them where you want to locate a crosspiece.
- Cut dadoes in the sides of the uprights to accommodate the crosspieces, making sure all the crosspieces in the same horizontal row will be at the same level.
- Bore holes into the uprights and crosspieces for the pipes; drill the holes 3 inches deep and 6 inches apart, angling them by about 5 degree so the pipes will tilt up slightly.
- Bolt the uprights to the studs, then cut the crosspieces to length and tap them in between the uprights with a mallet.
- Fix them in place with glue or by driving in screws at an angle.

How to set up adjustable lumber shelves

- A commercial lumber storage system mentioned consists of metal strapping and brackets that fit into holes in the strapping.
- Bolt the strapping directly to the wall studs, or to vertical supports fastened to non-exposed studs.
- Ensure that the straps are aligned laterally to allow you to position each row of brackets at the same height.
- For most applications, attach the brackets to the strapping about 24 to 36 inches apart vertically.

Chapter 21 - How to store tools

From shelves and racks to tool chests and partitioned drawers, numerous devices will eliminate clutter while keeping tools and supplies simply accessible. A few techniques are explained in the following pages.

For certain tools, particularly items that are valuable or dangerous enough to be out of the reach of children, wall mounted boxes are ideal.

For more traditional system of enclosed storage, you can build a tool cabinet or cupboard in the shop. But not every storage device needs to be elaborate. Suspending a tool from a fastener driven into a wall can work just fine.

How to install portable cabinets

- A box can be hung securely on a shop wall and simply moved if necessary.
- Build it from $\frac{3}{4}$ inch plywood with a hinged top.
- To hang the cabinet on the wall, cut a 45 degree angle bevel down the middle of a 1 by 6, and then crosscut the two pieces slightly less than the width of the box.
- Screw one of the pieces to the wall as a batten, with the bevel pointing up and facing the wall; anchor as numerous of the fasteners as possible in wall studs.
- Screw the other piece to the back of the box with its flat edge butting against the lip and the bevel pointing down and facing the back.
- The two pieces interlock when the box is hung on the wall.

Adapting drawers to hold small items

- The addition of some straightforward trays can make drawers much more efficient storage units, especially for small items like screws and washers, which can be simply lost.
- The jar organizer keeps different-sized jars in order.
- The shelf raises the smaller jars to make them more accessible.
- Begin by collecting the jars:
- Find some larger ones nearly the same height as the drawer and

some smaller ones about half that height.

- Make the divider by trimming a piece of $\frac{1}{2}$ inch plywood to fit it inside the drawer.
- Lay out the jars on the plywood and mark their positions.
- Use a hole saw to cut holes for the jars slightly larger than their actual diameters.
- Hold the divider and the shelf in place with a pair of plywood supports.
- Another useful drawer organizer is the sliding tray.
- The tray is a basic box that fits inside the drawer.
- The dividers are notched together and then secured with finishing nails.
- Attach a pair of slides to the drawer sides to support the tray.

Building a handsaw storage rack

- The handsaw storage rack saves space by storing saws upright.
- The handles fit on pieces of wood the same shape as the hole in the handle.
- The blocks are mounted to a holder that slides in grooves cut in the top and bottom of the box.
- Cut the parts of the box to size, and then equip your table saw with a $\frac{1}{4}$ inch dado blade.
- To accommodate the outside saw holders, cut $\frac{1}{4}$ inch-deep grooves 2 $\frac{1}{4}$ inches from each end of the top and bottom.
- Saw another groove on each piece centered between the first two for the third saw holder.
- Screw the top and bottom to the sides, and then tack the back in place.
- Trace the outline of the hole in each saw handle on a block of wood and cut out the piece.
- Glue and screw it to the saw holder, then screw a pivoting piece of wood to the top of the block to serve as a turnbuckle that will keep the saw in place when it is being stored.
- Use a saber saw or a band saw to cut handles in the holders to make it easier to slide the saws in and out of the box.
- Place them at staggered heights so they do not interfere with each

other.

- The dimensions described will make a box that can hold saw three saws.
- If you want to store more saws, simply make the top and bottom wider and space supplementary grooves $1\frac{3}{4}$ inches apart.

Organizing circular saw blades

- Keep your circular saw blades visible and protected in a custom-made storage box like the one above.
- Build the box from $\frac{1}{2}$ inch plywood, cutting it a few inches larger than your largest blade and wide enough to hold all your blades.
- Make the dividers out of $\frac{1}{4}$ inch plywood; first cut rectangles 1 inch less than the size of the sides, then saw them in half diagonally.
- Screw the frame together, then glue and nail the dividers to the bottom and back.
- Leave $\frac{1}{4}$ inch between the dividers.
- To keep the blades from rolling out of the box, cut a batten from scrap stock and nail it to the dividers near the bottom of the box.

Adding tool-tray dividers

- To protect tool edges in storage drawers, saw a 2 by 4 to a length equal to the space between the drawer sides.
- Then cut dadoes across one side of the board to hold the tools-in this case, narrow dadoes to accommodate file blades.

Storing hand tools

- The tool tray keeps different tools apart and similar ones together, helping to protect them while making a required item easy to locate. The tray has the supplementary advantage of being suspended from overhead joists so that it takes up no valuable work space.
- Start by bolting two 2 by 4s to joists, spacing them to accommodate the tray.

- Cut off the bottom ends of the 2 by 4s at a convenient height.
- Then, build the tray, cutting the sides from ½ inch stock, and the bottom and the dividers from ¼ inch plywood.
- Cut dadoes for the dividers according to how you wish to group your tools, and then screw the sides together and to the bottom.
- Glue the dividers in the dadoes and screw the sides to the 2 by 4s.
- Screw the back to wall studs, or, utilizing lead anchors, top concrete wall.
- If you plan to install the tray at an angle, drive the screws through wood wedges placed between the tray and the wall.

Utilizing a Lazy Susan type storage cupboard

- If your workshop has an unused corner, an area under a counter, For instance, install a commercial Lazy Susan type cupboard to store workshop tools and supplies.
- The design of the device makes any item on the trays simply accessible.
- The model described features a carousel with two trays that revolve around a metal shaft.
- Utilizing ¾ inch plywood, build a cabinet to house the carousel and support the metal shaft at both the top and bottom.
- Assemble the carousel following the manufacturer's instructions.

How to make a tool cabinet

- The tool cabinet described is handy for storing and organizing hand tools.
- While the entire unit is portable, the drawers are removable, making it possible to carry around just the tools that are required.
- Build the cabinet from either ¾ inch plywood or solid lumber.
- The size of the box will depend on your needs but 40 inches high by 30 inches wide by 15 inches deep is a good starting point.
- Position the divider in the center of the cabinet so that the spaces on both sides of it are equal, making the drawers interchangeable.
- Cut the pieces to size, and then prepare the sides of the cabinet and the divider for the drawers:

- Rout a series of $\frac{1}{4}$ by $\frac{1}{4}$ inch dados on one face of the sides and on both faces of the divider.
- Make the space between the dados equal to the height of the drawers, plus $\frac{1}{4}$ inch for clearance.
- Glue up the cabinet, shelf, divider, and door, utilizing the joint of your choice.
- Nail a leather strap to the inside of the door for hanging tools, add a wood strip to prevent small items from falling out, then attach the door to the cabinet with butt hinges.
- Then, build the drawers.
- Saw the pieces to size, utilizing $\frac{1}{4}$ inch plywood for the bottom; orient the panels so the grain of the face veneer runs from the front of the drawer to the back.
- Cut the sides slightly shorter than the depth of the cabinet if you are working with lumber, to allow for wood movement.
- Make the drawer front 12 inch wider and cut a rabbet along its bottom edge to conceal the bottom, and notch the top edge for a handle.
- Cut dados in the sides for dividers.
- Glue up the drawers; the bottoms should extend beyond both sides by $\frac{1}{4}$ inch to form sliders that fit in the cabinet dados.

How to make a tool cupboard

- The cupboard described features twin doors for storing small, light tools like chisels and screwdrivers, as well as a large main compartment for larger tools.
- Cut the components from $\frac{3}{4}$ inch plywood or lumber to the appropriate size, depending on the number of tools you own; the cupboard described is 48 inches square and 5 inches deep with 3 inch-deep doors.
- Then, assemble the cupboard utilizing the joinery technique of your choice.
- A through dovetail joint is one of the strongest and most visually pleasing options.
- But you could select a technique as straightforward as counter bored screws concealed under wood plugs.

- To help you install the shelves, lay the cupboard on its back and place the tools to be stored in their designated spots.
- Position the shelves accordingly and screw them in place.
- To keep supplies from rolling off a shelf or the bottom of the doors, glue a ledge along the front edge.
- If you want to subdivide a shelf, screw 1 by 1 cleats across it or install vertical dividers between the shelves.
- Equip one or both doors with slotted shelves to hold tools like chisels and screwdrivers.
- Bore a series of hole slightly smaller than the tool handles, and then saw a kerf from the edge of the shelf to the hole to enable you to slip in the blade.
- Screw the shelves to the door.
- Hang the doors on the cupboard with butt or piano hinges.
- Use three butt hinges per door.
- Mount the cupboard to the wall above your workbench, if desired, by screwing it to the wall studs.

How to make a fold-down bench and tool cabinet

- Ideal for small workshops, the storage cabinet that features a door that serves double-duty as a sturdy work exterior that folds up out of the way when it is not required.
- Mounted on a frame that is anchored to wall studs, the unit is built with an adjustable shelf and a perforated hardboard back for organizing and hanging tools as well as a work table supported by folding legs.
- The cabinet bench described can be made exclusively of $\frac{3}{4}$ inch plywood, except for the legs and leg rail, which are cut from 2 by 4 stock; the 1 by 3 frame; the 1 by 4 hinge brace assembly; and the hardboard back.
- Build the unit in three steps, starting with the frame, then making the cabinet section, and Lastly cutting and attaching the work table and legs.
- Cut rabbets in the frame rails and stiles, then glue and screw them together.
- Then, screw the frame to the studs in your shop.

- Be sure to position the frame so that the work exterior will be at a comfortable height, typically about 36 inches off the floor.
- Now build the cabinet section, cutting the parts to size.
- Before assembling the pieces, bore two parallel rows of holes on the inside face of one side panel and the opposing face of the divider.
- Drill the holes at 1 inch intervals about 2 inches in from the edges of the panels.
- By inserting commercially obtainable shelf supports in the holes, the height of the shelf can be adjusted to suit your particular needs.
- With the exclusion of the shelf, screw the parts together, then cut the hardboard to size and nail it to the cabinet.
- Fit the unit against the frame and use screws to attach the cabinet to the frame.
- Saw the parts of the workbench to size, and then screw the hinge brace rails and stiles and the bench top rail and stiles to the underside of the bench top.
- Attach the bench top to the bottom of the cabinet section with a piano hinge, making sure the two edges are perfectly aligned.
- With the workbench folded down and held parallel to the floor, measure the distance from the hinge brace rail to the floor and cut the legs to fit.
- Attach the legs to the rail with hinges, then screw levelers to the bottom of the legs and adjust them as necessary to level the bench top.
- Add a folding metal brace to each leg for added support, screwing the flat end of the brace to the hinge brace stile and the other end to the outside edge of the leg.
- Also cut a leg rail to fit between the legs and screw it in place.
- Lastly, install a hasp lock, screwing one part to the top of the cabinet and the other part to the bench top rail.

Building a handsaw holder

- Build a wall-mounted rack for handsaws with a few wood scraps, doweling, and some rubber hose.
- Cut the base from ½ inch plywood and the dividers from 4 by 4

stock; the dividers should be 10 inches long.

- Cut a taper at the end of each 4 by 4.
- Screw a 2 by 4 along one edge of the base, and then screw the dividers in place, leaving a $\frac{1}{2}$ inch gap between them.
- The stoppers are cut from 4 inch lengths of $\frac{1}{2}$ inch dowel and slightly larger rubber hose; use hose with ridges rather than smooth garden hose.
- Slip a saw into the rack from below, and then tug down on the handle.
- The stopper will pinch the blade in place.
- Mark the dowel's position and screw it to the base.

How to make a mobile clamp rack

- Clamps can be a nuisance to store.
- The sheer number accumulated in most shops-and their awkward size and shape can stretch even the most organized storage system to the limit.
- The mobile clamp rack described stores a wide diversity of clamps.
- With casters mounted under the base, the rack can be rolled to any part of the shop where clamps are required, and then stored against the wall.
- Start by cutting the rails, stiles, and crosspieces to size from 2 by 4 stock.
- Then join the pieces together utilizing lap joints and notches.
- To prepare the rails for the joinery, rout end rabbets that will fit into the notches and dadoes cut into the stiles.
- The rabbets should be $1\frac{1}{2}$ inches wide and $\frac{3}{4}$ inch deep.
- Then, notch the top end of each stile on three sides, then rout back to back dadoes near the bottom end and middle of the stiles; make the dadoes $3\frac{1}{2}$ inches wide and $\frac{3}{4}$ inch deep.
- Also cut a notch $3\frac{1}{2}$ inches wide and $\frac{3}{4}$ inch deep from the bottom of each stile.
- When you assemble the rails and stiles, align the two halves of each rail face-to-face and assemble with the stile.
- Screw the pieces together, driving the fasteners through the joints.

- To join the crosspieces to the rack, cut 3 ½ inch-wide dadoes in the middle of each and screw them in place.
- The middle crosspieces will rest on the median rail.
- The top pieces will rest on the outside shoulders of the notched top of each stile.
- Finish the rack by cutting the four pieces for the skirt from 2 by 4 stock and the base from ¼ inch plywood.
- Saw two notches in the base and skirt to accommodate the stiles, rabbet the ends of the skirt pieces, and screw them together to form a box.
- Use screws to attach the skirt to the base.
- Lastly, attach casters to the underside of the skirt at each corner of the rack and fasten the base to the stiles and bottom rail, driving the screws from underneath the base.

How to make a shelf for clamps

- Built from ½ inch plywood, the shelf described features a series of notches for supporting bar and pipe clamps along a shop wall.
- Cut the shelf about 10 inches wide and as long as you need for the number of clamps you wish to store.
- Cut the notches at 3 inch intervals with a saber saw and make them wide enough for the clamp bars or pipes; 1 ¼ inches is about right for most clamps.
- Then screw shelf brackets to the underside of the shelf, centering them between the notches.
- Fasten the shelf to a backing board of ½ inch plywood, and then anchor the board to the wall studs.

How to make and install the racks

- Shop walls make ideal storage areas for bar and pipe clamps.
- For bar clamps, nail two cleats across the wall studs.
- Position the upper cleat, made of plywood-high enough to keep the clamps off the floor; make the lower one from two 2 by 4s nailed together so that the clamps will tilt toward the wall.

- For pipe clamps, nail cleats of $\frac{3}{4}$ inch plywood to the studs and screw broom grippers to the cleats.
- Position the cleat on the wall so the clamps will rest about 1 inch off the floor.
- Then cut the base from 1 by 4 stock, and bore a row of holes into it at the same interval as the grippers.
- Fasten the base along the floor so the holes line up with the clamps.

Mounting glass jars under a shelf

- Screws, nails, and bolts can be stored in a diversity of containers, including tennis ball canisters, mason jars, or pill bottles.
- Mounting the containers under a shelf will keep the items out in the open without cluttering a work exterior.
- Fasten the container lid to the shelf, and then screw the container to the lid.

Making a scrapbox

- Use a scrapbox to keep from cluttering the shop floor with cut-offs, shavings, and other refuse.
- The design described can be built rapidly from $\frac{3}{4}$ inch plywood; casters allow the unit to be rolled where it is required and moved out of the way when it is not.
- Saw the sides and bottom to a size appropriate to your needs, then cut four corner blocks from 2 by 2 stock.
- Screw the four sides together, driving the screws into the corner blocks.
- Turn the box over and nail the bottom to the corner blocks and sides.
- Add a lip around the top to hide the plywood edges.
- Lastly, screw casters to each bottom corner and a pull handle at one end.

Chapter 22 – Work table tips

It is a truism that no workshop is ever large enough; it is equally true that no woodworker ever has enough tables, benches, sawhorses, stands, or props to support work in progress. The traditional workbench, nevertheless useful or necessary, is just the beginning.

For numerous uses, it is too high, too small, or too immobile to be helpful. When it is time to mark the elements of a joint or assemble the numerous pieces of a chair, a solid work table, like a library style table, can serve as the command center of your shop, becoming the focus of numerous operations.

This design features a spacious work exterior and sturdy building. The just drawback is size: one would need a fairly large shop to accommodate this table. For a smaller shop with cramped quarters, consider the folding table.

Offering almost as much exterior area as the library-style version, it can be folded out of the way against the wall when it is not required. Resting on sawhorses, this plywood sheet tabletop can be set up whenever a flat exterior is required, then be dismantled and put away when your venture moves on to another phase.

With its myriad uses, the sawhorse is also the workhorse of the shop. A sawhorse can serve as a set of legs for a fold-down work table or a straightforward prop for sawing stock. With a few notches cut into their crosspieces, horses can form part of the frame for a shop made glue rack.

Clamped to a 2 by 4 attached to a commercial roller, a sawhorse becomes a custom-built roller stand. Outfeed tables and roller stands that hold unwieldy panels or long planks significantly expand the versatility of tools like table saws, band saws, and drill presses.

Set up at the same level as a machine's table, or fractionally below it, these props can be as welcome as a second set of hands, enhancing a tool's capacity to handle large workpieces efficiently and safely.

Work exteriors can even be rigged to compensate for a lack of full-size stationary machines. A stand can be intended to let you mount a bench top tool at a comfortable working height. A three-in-one tool table can transform a router, saber saw and electric drill into mini-stationary tools.

Given a need and a few pieces of wood, numerous woodworker will devise

some way to improve his or her tools. The examples that follow are mere suggestions, for it is impossible to limit the imagination when the need arises for improving the workshop.

For numerous light woodworking chores, from marking out joints to assembling pieces of furniture, a straightforward work table fits the bill as well as a traditional woodworker's bench. This section features several table designs.

All are quick, easy, and inexpensive to build. The table described is sufficiently large and sturdy for most jobs if space is at a premium, a good compromise would be one of the fold-up types.

You can also conserve space by incorporating storage shelves, drawers, or cabinets in your design. For assembling carcasses and other pieces of furniture, you may find the low to the ground table handier than a standard-height work exterior.

Whichever design you choose, be cautious of the nails or screws you use to construct a table-particularly when fastening the tabletop to the frame. Take the time to countersink or counter bore screw heads and set nail heads below the exterior to prevent the fasteners from marring your work.

Making a library type work table

- The all-purpose table described is built with a combination of lumber and plywood.
- The dimensions a work exterior that is 5 feet long, 3 feet wide, and 3 feet high.
- Saw the legs to length from 4 by 4 stock, then prepare them for the rails:
- Cut a two-shouldered tenon at the top end of each leg with shoulders $\frac{3}{4}$ inch wide (inset).
- Then, cut the rails, stretchers, and braces to length from 2 by 4s.
- Saw miters at both ends of the braces so that one end sits flush against the inside edge of the legs and the other end butts against the bottom of the rails.
- Prepare the front, back, and side rails for assembly by bevelling their ends and cutting rabbets to accommodate the leg tenons.

- Screw the stretchers to the rails, spread glue on the contacting exteriors of the legs and rails, fit the pieces together, and screw the rails to the legs.
- Then, attach the braces to the legs and rails with screws.
- Cut the tabletop from $\frac{3}{4}$ inch plywood and screw it to the rails.
- Lastly, cut a piece of $\frac{1}{4}$ inch hardboard to the same dimensions as the top and nail it to the plywood as a replaceable protective cover.
- Be sure to set the nail heads below the exterior.

Building a low assembly table

- For operations that are awkward to perform on a standard-height table, use an assembly table.
- Ideal for jobs like gluing up carcasses, the table can be built simply in the shop with a small amount of wood.
- The dimensions for a work exterior that is about 12 inches lower than a standard table.
- Saw the legs from 4 by 4 stock and the rails and braces from 2 by 4s; cut miters at the ends of the braces so they butt against the legs and sit flush with the top of the rails.
- Screw the rails to the legs, and then fasten the braces to the legs and rails (inset).
- Then, saw the tabletop from $\frac{3}{4}$ inch plywood; it will overhang the rails by about 3 inches on all sides.
- Screw the top to the rails, countersinking the fasteners.
- Cut a replaceable cover from $\frac{1}{4}$ inch hardboard and nail it to the tabletop; set the nail heads below the exterior of the cover.

Making and installing a fold-down work table

- The table described incorporates a large and sturdy work exterior, but still conserves space by folding up against a wall when it is not in use.
- The dimensions yield a work exterior measuring 20 by 48 inches.
- Cut the bracing, legs, rails, and stretchers from 2 by 4 stock and screw the bracing between the wall studs (inset); there should be one brace for every pair of studs along the table's length.

- Fasten the front legs to the side rails utilizing carriage bolts and lock nuts; place washers on both sides of the legs.
- Leave the bolts just loose enough to allow the legs to pivot when the table is folded up.
- To complete the frame attach the front rails to the side rails.
- Add a 45 inch-long top rear rail and fasten two 17 inch long stretchers between the rear rail and the top front rail to provide added support for the top.
- Then, screw the top to the rails, countersinking the fasteners.
- To allow the table to fold down without binding, screw shims to the ends of the bottom side rails, then attach the table to the bracing with butt hinges; use two hinges for each outside brace,
- Lastly, drive an eye bolt into the bottom front rail and a catch into the wall to secure the table when it is folded up.

Supporting a fold-down work exterior on sawhorses

- Rather than building a framework for a fold-down work exterior, you can use a panel of $\frac{3}{4}$ inch plywood hinged to the wall and supported by sawhorses.
- The exterior can be of any size.
- Begin by setting the panel on two sawhorses; one edge of the panel should be flush against the wall.
- Mark a point on the panel at every wall stud, and then install butt hinges, screwing one leaf of each hinge to a stud and the other leaf to the panel at a pencil mark.
- To secure the panel when it is folded up, screw a notched piece of 2 by 4 to the stud closest to the middle of the panel at a height that will allow the notched end to slip over the edge of the panel.

Setting up a temporary work exterior

- Consisting of two sawhorses, six 2 by 4s and a plywood panel, even if the unit is inexpensive and easy to put together, yet it provides a large and stable work exterior that can be set up and disassembled rapidly can be sufficient enough.
- Start by fitting the sawhorses with crosspieces cut from 2 by 6

stock, then cut the 2 by 4s to the same length as the panel.

- In three of the boards, cut a notch about 8 inches from each end; the notches should be about 2 inches deep and as wide as the thickness of the crosspieces.
- Cut matching notches in the top edges of the crosspieces.
- Center the unnotched edge of the notched boards along the face of the other 2 by 4s and screw them together to form three T-fashioned tabletop supports.
- The sawhorse supports can be used to hold a large sheet of plywood for ripping, or a permanent top can be screwed to the 2 by 4s.

Chapter 23 – Sawhorses tips

Sawhorses have countless uses in the woodworking shop, from table legs to tool stands. Often it seems that their original purpose-to support boards for sawing-is just an afterthought.

It is easy to see why sawhorses are considered so versatile, for their compact design makes them especially useful in shops with limited floor space. Some commercial models, like the ones in the photo at right, can be adjusted to different heights and folded up for easy storage.

With commercial brackets, you can size sawhorses to suit your needs. Shop-made horses can be disassembled and put away after use. Different operations require different-sized sawhorses.

For supporting stock for hand sawing or holding large workpieces at a comfortable height, small horses about 18 inches high are ideal. Taller sawhorses are required if they are to be used to hold up a work exterior or as outfeed supports for a table saw.

They should be about $\frac{1}{4}$ inch lower than the saw table. Whatever the dimensions of your sawhorses, never make them taller than their length, as they will tend to be unstable.

How to use a commercial sawhorse brackets

- A pair of metal sawhorse brackets can help you transform a couple of 2 by 4s and 1 by 3s into a sturdy sawhorse.
- Saw the legs and crosspiece from 2 by 4s, and then cut a bevel at the bottom of the legs so they will sit flat on the floor.
- Fit the legs into the bottom of the brackets, insert the crosspiece and spread the legs; the brackets will grip the crosspiece and stabilize the horse.
- Screw the brackets to the legs and crosspiece.
- For added stability, add braces and a stretcher.
- The braces are cut from 1 by 3s and screwed to the legs, making sure that the ends are flush with the outside faces of the legs.
- For the stretcher, cut a 1 by 3 to size and screw it between the braces.

Building a knock-down sawhorse

- With just a small amount of lumber and plywood and a few minutes time, you can make a sturdy, knock-down sawhorse.
- Cut the legs from $\frac{3}{4}$ inch plywood, and then saw a 3 inch deep notch in the middle of the top of both pieces.
- Then, cut the crosspiece from 1 by 6 stock and saw a 1 $\frac{1}{2}$ inch deep slot 8 inches in from either end to fit into the legs.
- Angle the slots roughly 5 degree from the vertical so the legs spread slightly outward.
- For added stability, screw 4 inch long 1 by 2 cleats to the crosspiece on each side of the slots.

Assembling a frame-and-foot sawhorse

- Lightweight, compact frame-and-foot sawhorses can be built from 2 by 4 stock.
- Start by cutting the legs to a suitable height, and then prepare them to join to the other parts of the unit:
- Cut tenons at the bottom ends, rout through mortises halfway up the faces, and saw 1 inch deep notches in the middle of the top ends.
- Cut the feet to length and, for added stability, cut recesses along their bottom edges, leaving a 2 inch pad at each end.
- Rout mortises through the middle of the feet for the leg tenons.
- Then, saw the stretcher to fit between the legs and cut tenons at both ends.
- Cut the crosspiece and saw a notch 4 inches from either end that will fit into the notch at the top of the legs.
- To reinforce the mortise and tenon joints, saw a pair of kerfs in the end of each tenon and make wedges to fit into the kerfs.
- Tap the wedges in to expand the tenon when the joint is assembled.

Making a heavy-duty sawhorse

- Reinforced by a stretcher, braces, and straightforward joinery, the

sawhorse will endure for years as a sturdy work exterior.

- Saw the crosspiece to length from a 2 by 6 and cut dadoes in the edges about 4 inches from either end to accommodate the legs.
- Angle the dadoes roughly 10 degree from the vertical.
- Then, saw the 2 by 4 legs to length and cut 1 ½ inch-deep angled notches into their outside edges to house the braces.
- The top of each brace should rest about 1 ½ inches below the tops of the legs.
- Also cut bevels at both ends of the legs so they will sit flat on the floor and lie flush with the crosspiece.
- The stretcher is a 2 by 4 cut to the same length as the crosspiece; cut a notch in each end to line up with the brace, leaving a 1 ½ inch shoulder.
- Saw the braces from 2 by 6 stock, mitering the ends to be flush with the outside faces of the legs and sawing a 2 inch deep notch in the middle of the top edge for the stretcher.
- Lastly, glue up the sawhorse, strengthening the joints between the legs, crosspieces, and braces with screws.

Building a folding sawhorse

- Made exclusively from 1 by 6 stock, with a hinged crossbrace and top, this lightweight sawhorse folds flat to store simply in even the most cramped workshop.
- Cut the legs and rails to length.
- Then, cut notches in the pieces for half-lap joints.
- Use T type half-laps to join the legs to the bottom rails, and corner half-laps to join the top rails to the legs.
- Assemble and glue the two sections of the horse, and reinforce the joints with screws.
- When the glue has cured, join the two sections at the top rails with a continuous piano hinge.
- Lastly, cut the crossbrace; be sure it is long enough so when the horse legs spread, the piano hinge is recessed between the top rails.
- Saw the crossbrace in half and connect the pieces with a piano hinge, making sure that the hinge is installed so the brace will

- pivot upwards.
- Then, fasten the crossbrace to both side rails, again utilizing piano hinges.

Sawhorse panel support frame

- When sawing large panels, appropriate support is required to keep the work from buckling and binding on the blade as the cut is made, and to stop the cut off from falling away as the cut is completed.
- To accommodate these cumbersome jobs, construct this 4 by 8 foot support frame, which is simply held in place with notched wood blocks.
- Cut two 4 foot and two 8 foot lengths of 2 by 4 for the ends and sides of the frame.
- Cut dados six inches from the ends of the 4 foot lengths and 18 inches from the ends of the 8 foot lengths for the cross half-lap joints that hold the frame together.
- Then cut two 4 inch long blocks from 2 by 4 and saw a two-inch-deep notch, wide enough to fit over 1 ½ by 1 ½ inch deep notches in the middle of the crosspieces of the sawhorses you plan to use.
- Screw the blocks to the bottom of the end pieces and assemble and glue up the frame.
- Secure the frame to the sawhorses by mating the notches in the blocks with those in the crosspieces.

Building the box

- Constructing a box with different width, length, and height dimensions will provide you with a work exterior that can be used at three levels.
- The too exterior of the box, For instance, can be either 24, 30, or 36 inches high.
- Saw all the pieces from 1 by 4 stock, making eight boards 36 inches long, eight boards 23 ¼ inches long, four that are 30 inches long, and four more 29 ¼ inches long.
- Utilizing half lap joints assemble the boards into six frames: two

measuring 30 by 36 inches, two measuring 23 ¼ by 29 ¼ inches, and two more 23 ¼ by 36 inches.

- Once the frames are assembled, cut a 3/8 by 3/8 inch rabbet along all four edges of each of the six frames.
- Use a lightweight wood like pine to make the box simply portable.
- If you select to reinforce the joinery at the curves with screws, be sure to countersink the screw heads.

Chapter 24 – Work support tips

Supporting long plank and large panels as they are fed across a saw table ranks as one of the most cumbersome tasks in the woodworking shop. Outfeed tables can be attached to most saws, but they tend to take up a lot of floor space.

Once side supports are added to your machine, your shop may become an obstacle course. Commercial roller stands make better use of shop space; they can also be moved simply to where they are required and adjusted to whatever height is suitable.

The shop-made stands described on the following pages, share the advantages of the store-bought diversity, with the supplementary benefit of being easy and inexpensive to build.

They can also be dismantled and stored when not required. There are other work support jigs that make life easier in the shop. The vise extension stand For instance, solves the issue of keeping long boards edge-up in a bench vise.

How to set up a temporary stand

- With just a sawhorse, two C clamps, and a commercial roller, you can make a straightforward roller stand.
- Make a T fashioned mast for the roller that is long enough to hold it at a suitable height.
- Screw the roller to the horizontal part of the mast.
- Add a brace to the side of the horse for clamping the mast in place:
- Cut a 1 by 4 to span the legs between the sawhorse bracket and the original brace and screw it to the legs.
- Cut a 1 by 2 to span the two braces and screw it in place as a vertical guide for the mast.
- To secure the roller stand to the sawhorse, clamp the mast to the braces, making sure it is flush against the guide.

Building an adjustable roller stand

- To build the roller stand, start by constructing the frame for the roller, cutting the four pieces from 1 by 4 stock.

- Glue the frame together with butt joints, adding screws to reinforce the connections.
- Then bore a hole in the middle of each side of the frame for a ¼ inch diameter carriage bolt.
- Locate the hole 3 inches from the bottom of the frame. Insert the bolts from the inside of the frame and screw the roller to the too.
- As well as the commercial roller, two variations that permit you to feed the workpiece from any direction.
- Cut the remaining pieces of the stand from 1 by 6 stock, referring to the dimensions provided, and then rout a ¼ inch wide slot down the middle of the two uprights; the slot should be about 14 inches long.
- Screw the crosspiece to the uprights, aligning the top of the piece with the bottom of the slot.
- Fasten the uprights and rails to the feet.
- To guide the roller frame, nail 1 by 1 cleats to the uprights about ¼ inch in from the edges.
- To set up the stand, position the roller frame between the uprights, fitting the carriage bolts into the slots.
- Slip washers on the bolts and tighten the wing nuts to set the height of the roller.

Making and utilizing the stand

- Also known as a bench slave, a vise extension stand is used to support the free end of a long board clamped in the shoulder vise of a workbench.
- To build the stand, cut the upright to length and, starting 5 inches from the bottom, saw angled notches at 2 ½ inch intervals along its length.
- Cut the notches about 1 inch long and ½ inch wide.
- Then saw the feet to length and cut recesses along their bottom edges.
- Join the feet with a cross lap joint:
- Cut a lap in the top edge of one foot and in the bottom edge of the other foot.
- Glue the two feet together.

- Once the adhesive is dry, screw the upright to the feet.
- Cut the support piece and swivel bars, angling the top of the support piece about 10 degree.
- To join the support piece to the swivel bars, bore holes for 3/8 inch diameter dowels through the piece and near the ends of the bars, and slip the dowels into the holes; glue them in place.
- To use the stand, insert the dowel at the top end of the swivel bars in the appropriate slot in the upright for the height you need and prop your workpiece on the support piece.

Making and utilizing the jig

- For making circular cuts out of large panels on the band saw, use a jig.
- Build the jig from $\frac{3}{4}$ inch plywood, cutting the pieces so the top of the jig is level with the saw table when the feet are screwed or clamped to a work table.
- Before assembling the jig, drive a $\frac{1}{4}$ inch-long screw as a pivot point through the center of the top piece so the tip of the screw ventures from the exterior by about $\frac{1}{2}$ inch (inset).
- Then screw the top and feet to the sides of the jig, and attach the triangular fashioned support brackets to the top and sides; be sure to countersink the fasteners.
- Before setting up the jig, mark the center and circumference of the circle on the workpiece.
- Then cut from the edge of the piece to the marked circumference and back to the edge, creating a starting point for the circular cut.
- Now set up the jig:
- Attach it to a table and place the workpiece on the jig so the marked center of the circle contacts the pivot point.
- Position the table so the blade butts against the marked circle and the pivot point is aligned with the center of the blade and the machine's center line.
- Cut the circle by rotating the workpiece into the blade.

Chapter 25 – Extension table tips

Stationary machines like table saws, band saws, and drill presses come from the manufacturer equipped with tables that are adequate for most routine operations.

But there are some tasks crosscutting long planks or panels on the table saw, performing long cuts on the band saw, and smoothing large pieces with a sanding drum on the drill press-that can be awkward or even dangerous to attempt without extending the size of the machine's table.

Often, the solution creates a new issue. Nevertheless, because increasing the size of a stationary machine with a permanent addition can crowd even the roomiest workshop.

The following pages describe a diversity of devices for extending the work area of woodworking machines. While easy to build and use, each jig is intended to be eliminated or folded out of the way.

Building an extension table for a radial arm saw

- Made exclusively from 2 by 4 and 1 by 3 stock, the extension table can be attached to the outfeed or infeed ends of a radial arm saw table.
- Utilizing 2 by 4s, cut the legs, rails, and stretchers to suit the dimensions of your saw, making the length of the legs equal to the distance between the top of the saw table and the shop floor, less the thickness of the stretchers.
- Attach the rail stretchers so that their tops are flush with the rail's top edges.
- Attach the leg stretchers to the legs, then screw the legs to the inside edges of the rails.
- Make certain the outside rail stretcher is butted against the tops of the legs.
- Cut the braces from 1 by 3s to reach from the bottom of the second rail stretcher to the inside edges of the legs.
- Miter the ends of the braces and screw them in place.
- To fasten the extension table to the saw table, cut two wood strips and screw one end of each piece to the underside of the inside rail

stretcher.

- Set the extension table flush against the saw table and fasten the other end of the strips to the underside of the table, utilizing shims or spacers as required.
- If you prefer to span the table's rails with rollers (inset), rather than wood stretchers, cut the rail stretchers long enough to fasten them to the bottom edge of the rails.
- Then screw commercial rollers to the tops of the stretchers, placing shims under the rollers, if necessary, to set them level with the top of the saw table.

Outfitting a table saw with a fold down outfeed table

- A handy extension to your saw table for cutting long stock, the shop-made jig swings down out of the way when it is not required.
- Start by cutting the top, sides, and support brackets from $\frac{3}{4}$ inch plywood, sizing the pieces to suit your needs.
- Then saw the braces and cleat from 1 by 2 stock, adding an angled notch at the bottom end of both braces.
- Screw the sides to the top, countersinking the fasteners.
- Then, get ready to attach the jig to the saw housing.
- First, attach an angle iron to each side of both support brackets.
- Then, have a helper hold the top against the saw table, making sure the two exteriors are level; leave a slight gap between the top and saw table so the jig will fold down without jamming against the table.
- Now determine the position of the support brackets by butting each against the inside face of a side piece.
- Mark the holes in the angle irons on the saw housing.
- Drill a hole for a machine screw at each mark and fasten the angle irons to the housing.
- Reposition the jig against the saw table and bore holes for a carriage bolt through the sides and support brackets.
- Use washers under the nuts and bolt heads, and between the sides and brackets.
- Attach the braces to the sides with bolts spaced about 8 inches from the bracket bolts.

- Leave all the bolts loose enough for the sides and braces to pivot.
- Then, holding the jig level again, swing the braces toward the saw housing.
- Mark the points where the braces contact the housing and screw a cleat to the housing so the cleat's top exterior aligns with the two points.
- To set the jig in position, rest the braces on the cleat.
- To fold the table down, raise the top slightly, move the braces off the cleat and swing the jig down.

How to build an extension table for a band saw

- An auxiliary band saw table will significantly increase the machine's versatility.
- An extension table is especially handy for cutting long or wide pieces.
- Utilizing $\frac{3}{4}$ inch plywood, cut the top of the jig to a suitable diameter.
- Cut out the center and the edge to fit the top around the saw table and throat column.
- Saw a 1 $\frac{1}{2}$ inch-wide channel between the cut outs so the top can be installed without removing the blade.
- Then, prepare two cleats that will be used to attach the saw table to the jig top.
- For these, two 1 by 3s should be cut a few inches longer than the saw table.
- Then position each one in turn against the side of the saw table with threaded holes, so that they are $\frac{3}{4}$ inch below the table exterior, with at least $\frac{1}{4}$ inch of stock above the holes.
- Ensure that your machine has these holes; most band saws have them for mounting accessory rip fence.
- Depending on the position of the threaded holes on your saw table, you may have to position the top of the cleats closer than $\frac{3}{4}$ inch to the machine tabletop.
- In that case you will have to rout grooves for the cleats on the underside of the top to allow the tabletop to sit flush with the machine's table.

- Mark the hole locations on the cleats, bore a hole at each spot, and fasten the cleats to the saw table with the screws provided for the rip fence.
- Then place the tabletop on the cleats and screw it in place; be sure to countersink the screws.
- The top should sit level with the saw table.
- You may need to cut clearance notches so that you can reach the machine screws once the jig is completed.
- To eliminate the jig, loosen just the machine screws, leaving the cleats attached to the top permanently.

Fitting a drill press with an extension table

- The small table typical of most drill presses will not adequately support numerous large work pieces.
- A customized extension table for the tool will enable you to keep a workpiece level as you feed it into an accessory like a sanding drum.
- Start by cutting a piece of $\frac{3}{4}$ inch plywood into a square with dimensions that suit your needs.
- Then mark a line down the middle of the piece and draw two circles centered on the line.
- Locate one about 4 inches from the back edge, sizing it to fit snugly around the drill press column.
- Locate the second hole under the chuck; make its diameter about $\frac{1}{2}$ inch greater than the largest accessory you plan to insert into the chuck.
- To help you pinpoint the center of hole install a bit in the chuck and measure the distance from the column to the bit.
- Prepare to install the jig on the drill press table by cutting two recesses along its back edge, leaving a rectangular "ear" that protrudes behind the back hole.
- Then bore a hole through the ear for a $\frac{1}{4}$ inch diameter carriage bolt.
- Then, saw the jig in two along the centerline and cut out the two circles.
- You may need to make other cuts to clear protrusions on your

- particular drill press.
- On your model, a notch might be required for the table height adjustment rack.
- Lastly, screw a butt hinge to the front edge of the jig to join the two halves together.
- The carriage bolt and wing nut will clamp the table in place.

Tool stands and tables

A stand or table can transform a portable power tool into a reasonable facsimile of a full-size stationary machine. What they concede in power to their larger cousins, bench-mounted tools compensate with portability, ease of storage, and lower price.

There are commercial stands for bench top tools, but you can simply build a stand. Storage shelves and drawers can be added to customize the basic design. There is one requirement, Nevertheless:

Ensure the stand's exterior area is large enough for your needs and that it supports the tool at a comfortable height. The extension router table not just converts a router into a mini-shaper, but can be simply eliminated when it is not required.

The three-in-one portable power tool table features replaceable inserts for a router, an electric drill, and a saber saw. Because of its central role in woodworking, the router merits a dedicated table in most shops.

Building a bench top tool stand

- The stand can be constructed from 4 by 4 and 2 by 4 lumber and plywood.
- Saw the legs from 4 by 4s and the rails from 2 by 4s, sizing the pieces to suit your needs.
- Notch the legs at the top and 6 inches down from the top to fit the rails, and then cut matching rabbets at the ends of all the rails (inset).
- Glue up the legs and rails, adding countersunk screws to reinforce the joints.
- Cut the top from $\frac{3}{4}$ inch plywood.

- If you plan to place a table saw on the stand, saw a square hole out of the center of the top to allow sawdust to fall through; place a box underneath to catch the waste.
- Lastly, screw the top to the legs and rails, again countersinking the fasteners.
- When utilizing a tool on the stand, secure it to the top with screws or clamp.

Making and mounting a removable router table

- Attached to a workbench or table, the extension table serves as a compact router table that can be stored when it is not required.
- Size the parts according to your needs.
- Start by cutting the top from 3/4-inch plywood, and the rails and braces from 2 by 4 stock.
- Saw the rails 6 inches longer than the width of the top so they extend under the top and can be fastened to the underside of the bench utilizing nuts and hanger bolts.
- The hinged braces should be long enough to reach from the underside of the rails to a leg rail on the bench.
- Cut a bevel at the top end of the braces and an angled notch at the bottom end.
- The router is attached to the top with a square sub base made of 1/4 inch clear acrylic.
- Several steps are necessary to fit the base to the tabletop and then to the router.
- First, lay the square sub-base in the center of the table, clamp it in place, and mark its edges with a pencil.
- Mark the center of the sub base and drill a pilot hole completely through the base and the tabletop.
- Eliminate the sub-base and turn your attention to the tabletop.
- Use your router to plow a 1/4 inch-deep recess within the pencil outline of the sub-base.
- Then, utilizing the pilot hole as a center and your router as a template, cut a round hole through the tabletop the size of your router's standard base.
- The tabletop is now ready.

- In the sub-base, drill a hole in the center that is slightly larger than your largest router bit, and screw the base to the router, utilizing countersunk machine screws.
- Lay the sub-base in the table recess and screw it down, countersinking the wood screws.
- All exteriors should be flush. For a fence, cut two pieces of $\frac{3}{4}$ inch plywood and screw them together in an L shape.
- Saw a notch out of the fence's bottom edge to accommodate your largest bit, and then screw on four fence supports for added stability.
- Attach a clear semi circular plastic guard with a hinge to allow it to be raised out of the way (inset).
- The fence is clamped in place.

Building a bench top router table

- The bench top table can be a full size router table with most of the features of the produced version, including a pivoting, rapidly adjustable fence.
- Begin by cutting the top from $\frac{3}{4}$ inch plywood, sized to suit your needs; the table measures 24 by 36 inches.
- The four top rails should then be cut from 1 by 2 stock and screwed in place countersinking all screws, here and in future steps, and the entire top should be covered with a piece of $\frac{1}{4}$ inch plastic laminate, chamfered at the edges.
- Turn the table over so you can screw supports around the inside edges and attach the legs to the rails and top.
- The supports, legs, and feet can be constructed of $\frac{3}{4}$ inch plywood; the final dimensions will be determined by the size of your table.
- Ensure that the legs are at least long enough to furnish ample room for your router.
- To prepare the tabletop for the router, drill a hole about 8 inches from the front center; make it slightly larger than your largest router bit.
- On the underside of the top, center the router over the hole and trace its outline.
- Use the router to plow a $\frac{1}{4}$ inch recess within the outline to

accommodate your router base plate or, make an acrylic sub-base and mount it.

- Mark the location of the base plate screw holes, drill counter bore holes, and you will be ready to fasten the router in place.
- Then, construct the fence about 6 inches longer than the top out of two pieces of 1 by 3 stock screwed together in the form of an L.
- Through the base of the L, drill a hole for a $\frac{1}{4}$ inch carriage bolt about six inches from one end.
- Now center the fence about 6 inches from the rear of the top, mark the position of the hole, and drill for the carriage bolt.
- Slip a bolt through the hole; utilizing that as a pivot, swing the right end of the fence forward.
- When the fence reaches the hole you cut for the router bit, mark the hole's position on the fence.
- That is where you will cut a clearance notch to accommodate your largest router bit.
- Make a guard that is hinged so it will swing out of the way.
- Screw your router to the top and assemble the fence by inserting the carriage bolt from the bottom, utilizing washers and wing nuts to tighten it.
- Adjust the fence for any width of work by pivoting it into place and securing the free end with a C clamp.

Bonus Chapter - List of technical terms

Bench dog:

- A round or square peg of metal or wood that fits into a hole in a workbench to grip and hold a workpiece in place.

Bevel cut:

- A cut at an angle from face to face along the length or width of a workpiece.

Box joint:

- Identical interlocking fingers that mesh to form a corner joint.

Butt joinery:

- A technique of joining wood in which the end or edge of one board is set squarely against the face or edge of another.

Carcase:

- A box-like building that constitutes the body of a piece of furniture.

Cheek:

The face of the venturing tenon in a mortise-and-tenon joint.

Circuit:

- Continuous path for electrical current; from the main service panel in a house or garage, a branch circuit runs to a series of outlets, wall switches, and light fixtures, and returns to the panel.

Counterbore:

- To drill a hole that permits the head of a screw or bolt to sit below a wood exterior so it can be concealed by a wood plug.

Countersink:

- To drill a hole so that the head of a screw or bolt will lie flush with or slightly below the exterior of a workpiece.

Crosscut:

- A saw cut across the wood grain of a workpiece.

Dado:

- A rectangular channel cut into a workpiece.

Decibel:

- The standard measuring unit of sound intensity; the decibel (db) scale extends from 0 to about 130, with 0 representing barely perceptible sounds and 130 delineating the regular pain level.

Dedicated circuit:

- An electrical circuit to which just one tool or fixture is connected.

Dovetail joinery:

- A technique of joining wood at curves by means of interlocking pins and tails; the name is derived from the distinctive shape cut into the ends of the joining boards.

Dowel:

- A wood pin used to reinforce certain types of wood joints.

End cap:

- A piece of wood that covers each end of the top slab of a workbench; bolted to the slab and glued to the aprons by means of dovetail or finger joints.

Face gluing:

- Bonding several boards together face-to-face to form a denser workpiece.

Face jointing:

- Utilizing a jointer to cut shavings from the face of a work piece until it is flat and square with the edge.

Face vise:

- A vise that holds work against the front apron of a workbench.

Featherboard:

- A piece of wood cut with thin fingers or "feathers" at one end; used in conjunction with clamps to hold a workpiece secure against the fence or table of a power tool.

Fence:

- An adjustable guide intended to keep the edge or face of a workpiece a fixed distance from the cutting edge of a tool.

Furring strip:

- A thin board that is nailed to a wall or ceiling to provide a flat or level exterior for securing drywall or panelling.

Ground-fault circuit interrupter (GFCI):

- A type of electrical outlet that trips instantly when it detects a

short-circuit leak in current.

Hanger bolt:

- A bolt with no head; one end of the bolt has screw threads while the other end features machine threads.

Inlay:

- A decorative strip of metal, hardwood, or marquetry that is glued in a groove cut into a workpiece.

Joist:

- A horizontal support for a floor.

Kerf:

- A cut made in wood by the thickness of a saw blade.

Kerf splitter:

- A metal device that holds a kerf slightly open while a saw cut to prevent the blade from binding.

Kickback:

- The tendency of a workpiece to be thrown back in the direction of the operator of a power tool.

Knockdown fitting:

- A piece of hardware that accepts a screw or bolt, allowing the quick assembly and disassembly of a workbench or other furniture.

Lap joint:

- A type of joint in which matching dadoes or rabbets overlap to connect two boards.

Lead anchor:

- A type of fitting that is inserted into a hole in concrete or masonry; expands to hold a screw or bolt securely.

Leg vise:

- A vise that secures stock to the front left-hand leg of a workbench.

Miter cut:

- A cut that angles across the face of a workpiece.

Mortise:

- A rectangular, round, or oval-fashioned hole cut into a piece of wood.

Mortise-and-tenon:

- A joint in which a venturing tenon on one board fits into a mortise on another.

Push block or stick:

- A device used to feed a workpiece into the blade, cutter head, or bit of a tool to protect the operator's fingers.

Rabbet:

- A step-like cut in the edge or end of a workpiece; typically forms part of a joint.

Rail:

- A board running along the bottom edge of a tabletop to which the legs of a table can be attached.

Service entrance:

- A box including circuit breakers or fuses, from which power is distributed to house branch circuits.

Shoulder:

- In a mortise-and-tenon joint, the part of the tenon that is perpendicular to the cheek.

Shoulder vise:

- A fixed type of face vise with a jaw that moves to clamp a workpiece against the front apron of a workbench.

Sliding dog block:

- A wood block, part of the tail vise of a work bench, that applies the clamping face to hold a workpiece between the bench dogs.

Static pressure:

- A measure of the friction encountered by air as it moves through a duct; often expressed in inches per foot.

Stretchers:

- A board running between the legs of a workbench to provide supplementary support.

Stud:

- A vertical member forming walls and supporting the framework of a building.

Tail vise:

- A screw-type vise on the right-hand end of a workbench incorporating a sliding dog block to secure stock on the top exterior of the bench.

Tenon:

- A protrusion from the end of a board that fits into a mortise.

Truing:

- Squaring the end of a blade or the working exterior of a grinder wheel so that it conforms to its original shape.

Truss rod:

- A type of threaded metal rod used to reinforce the legs and stretchers of a workbench.

Wheel dresser:

- A star-wheel or diamond-point device used to true the working exterior of a grinding wheel and expose fresh abrasive particles.

BOOK 3

12

PROJECTS AND PRACTICAL TECHNIQUES
YOU SHOULD APPLY

Paul Berger

Chapter 1 How to make an End Table

When designing an end table, my objective is to make a modest piece that would be robust, yet appear light, and embrace subtle particulars that entice you to look closer, such as a 22-in. high table is based on straight, crisp lines and sharp curves.

The sense of lightness is strengthened by the legs, which taper to half their square dimension from top to bottom. And the angled joinery required to fit the legs to the aprons isn't hard.

You can mortise the legs with a router and jig, and cut the apron's angled tenon shoulders with a table saw. At first glance the table seems to be made exclusively of cherry; but a narrow rabbet in each leg's outside corner discloses that the legs are essentially three different woods: layers of cherry and maple laminated to a black walnut core, which seems as a thin line in the rabbet's inside corner.

The various parts of the table also relate to each other well. The leg rabbets are 5/16 in. square, the top overhangs the frame merely ¼ in. and the apron is set back from the face of the leg less than 1/8 in., the thickness of the outer cherry laminate.

Don't let the straightforwardness full you into carelessness. Since of the crisp lines, an error will stick out like a sore thumb. Entirety must be fashioned exactly. To achieve this precision, first make a full-size drawing to help you work out productions and measure angles and dimensions.

For this table, drew an elevation of two legs and one apron and a plan view of two aprons and one leg. Also contemplate building and assembly particulars, for instance if the tenons don't meet in a miter.

If they did, the leg would be weak with so little wood amongst the tenon ends and the rabbet. Also, the apron's 3/8 in. thick tenons are offset with a 5/16 in. shoulder on the outside and 1/16 in. shoulder on the inside, to position the tenon as close as possible to the middle of the leg for strength.

By make use of haunched tenons the full width of the apron, the top of the leg is stronger and you don't need clamp the mortise sides to the tenon cheeks when gluing.

Lastly, keep 1/16 in. space amongst the end of the tenon and the bottom of the mortise for excess glue that could compress and split the top of the leg while assembly.

Stock

- 2 Aprons made of Cherry, 3 degree $3/4 \times 2 \times 16 \frac{3}{16}$ in
- 2 Aprons Cherry $3 \frac{3}{4} \times 2 \times 22 \frac{3}{16}$ in
- 4 Legs made of Black walnut 90 degree $1 \frac{5}{8} \times 1 \frac{5}{8} \times 21 \frac{1}{2}$ in
- 8 Laminates made of Cherry 90 degree $1/8 \times 1 \frac{7}{8} \times 21 \frac{1}{2}$ in
- 8 Laminates made of Maple 90 degree $1/10 \times 1 \frac{7}{8} \times 21 \frac{1}{2}$ in
- Cleats made of Cherry 90 degree $3/4 \times \frac{3}{4} \times 14 \frac{3}{8}$ in
- Cleats made of Cherry 90 degree $3/4 \times \frac{3}{4} \times 20 \frac{3}{8}$ in
- Top made of Cherry plywood 90 degree $1/2 \times 18 \times 24$ in
- Edge facings made of Cherry Mitered $1/4 \times 9/16 \times 18 \frac{1}{2}$ in
- Edge facings made of Cherry Mitered $1/4 \times 9/16 \times 24 \frac{1}{2}$ in
- Flat-head 6 by 1 in
- Supplementary wood screws

Procedure

- Once you made the drawings, develop the bill of supplies, necessary angles and dimensions.
- Initially, leave all about 1 in longer than called for and trim later.
- Also note that the bill of supplies recommends some pieces be left oversize to simplify assembly; the plywood edge facing, or edge banding, for instance, is easier to apply if it's a bit wider than the thickness of the plywood it's glued to.
- Begin building the legs by gluing, one at a time, the maple laminates and then the cherry laminates to the black walnut.
- Spread the glue sparingly and equally.
- You can glue and clamp laminates on two legs at the same time if you sandwich the laminates amongst the walnut.
- If you spread the glue neatly, you won't need wax paper amongst the laminates to keep them from sticking to each other.
- By beginning with oversize, 1 5/8 in. square walnut leg stock, you can clamp directly to the wood without pads, since clamp-dented wood will be ripped away later on.
- Use three clamps, applying pressure from the middle clamp first and wiping away excess glue with a damp rag.
- If you wait until the glue is dry and then chisel it off, you can dull your tools or chip away enough wood to make the leg look as if mice troubled it.
- After the glue has cured, saw or plane and scrape the swollen laminate edges flush with the leg stock.
- You can eliminate this excess with a smoothing plane, but I typically rip it on the table saw after fitting a 3/4 x 1 1/2 x 18 auxiliary fence to the rip fence.
- Since of the low height of the auxiliary fence, the laminate doesn't interfere with the accuracy of the cut.
- The walnut core bears in contradiction of the fence and the laminate overhangs it while you rip the excess from the leg's other side.
- When ripping the excess from the first maple laminate, set the auxiliary fence 1 5/8 in. from the blade.
- If you make use of a hollow-ground blade for these narrow rip

cuts, the wood won't tear and the surface will almost be planer smooth.

- I finish the surface with a sharp cabinet scraper In advance gluing on another laminate.
- Recall to move the fence away from the blade as supplementary laminates are glued to the leg.

How to cut the leg mortises

- After all the laminates are glued in place, each leg will be 1 7/8 in. square and must be ripped on the inside surface and completed 1 3/4, in. square in advance mortising.
- I make use of a plunge router and the jig above to mortise the legs to accept the haunched tenons.
- The jig is a three-sided box in which the leg is situated in contradiction of a stop, shimmed to height and clamped on one side.
- The router's fence bears in contradiction of one side of the jig, and the distance of the mortise is determined by stops set on the other side of the jig to bound router base travel.
- My square-base plunge router has three depth settings, and I typically make use of one for 5/16 in. deep mortise for the haunch and one for a 13/16 in deep mortise for the main part of the tenon.
- After positioning the leg and setting the jig's stops for 2-in. long mortises, I gradually plunge a 3/8 in. straight bit into all the legs until I've reached the haunch depth.
- Then, I rearrange the stops for the 1 9/16 in. long tenon and slowly plunge to the tenon depth.
- Since the mortise is offset to one side of the leg, turn the leg end for end and rearrange the jig to cut the mortises on their opposite side.
- After routing each mortise, I square the curves with a chisel and mallet, and then to some extent undercut each one to receive the angled tenon end.
- Afterward, rip the full-distance taper in the leg on the table saw with the plywood jig.
- The jig should hold the leg snugly as you taper it from 1 3/4 in. square at the top to 7/8 in. square at the bottom, which is large enough not to cut into carpet or dent a wooden floor.
- Cut the same amount from each of the leg's two inside surfaces, but leave the dimensions to somewhat heavy so each after can be tried on the jointer.
- Lastly, rabbet the outside corner of each leg to reveal the laminates.

- I eliminate most of the waste by ripping the rabbet to somewhat smaller.
- Then, I finish the rabbet to 5/16 in. square with a straight bit in a table-mounted router.
- Since most of the waste was eliminated on the table saw, the router will leave surfaces that merely need light sanding.
- Be cautious not to round over the curves of the rabbet when sanding.

How to make the aprons

- The apron ends and shoulders are angled to fit the leg's full-distance taper with some modest table saw setups.
- In advance cutting the aprons to distance, you should mark an X on their best side.
- Then, measure the angle amongst the leg and the apron and the aprons distance including tenons.
- I measure the angle with a sliding bevel and duplicate it amongst the miter gauge and the blade, and then crosscut one end of each apron.
- By clamping a stop to the gauge, you can cut duplicate distances of the two long aprons in advance rearranging the stop to cut the short ones.
- To cut the tenon cheeks, I make use of a jig made of two pieces of plywood with a piece of wood, the thickness of the saw fence, sandwiched in amongst.
- The plywood edges slide on the table and the jig is guided by the fence.
- To cut the cheeks, I clamp the apron to the jig so the angled end of the apron is flat on the table, set the blade height at 3/4 in. square to the table, and locate the fence to leave the proper-size offset tenon.
- To cut the shoulders, eliminate the tenon jig and make use of the miter gauge previously set for the shoulder's angle, based on the leg's taper.
- Clamp a 1x2x6 block to the rip fence about 6 in, in front of the blade and position the fence for 3/4 in long tenon by measuring amongst the blade and the block.
- Make use of the block as an end stop provides clearance amongst the blade and rip fence to prevent the cut off from getting trapped and kicking back.
- When cutting the tenon, butt the end of the rail in contradiction of the block and then grip the rail firmly to the miter gauge fence as you make the cut.
- Set the blade height at 1/16 in. for the inside shoulder and test the cut on a scrap to ensure the shoulder is parallel to the rail's end.

- Since of the offset tenon and the opposing angles on opposite ends of the apron, you will have to cut the two right hand, 1/16 in. shoulders, reverse the miter gauge angle and cut the left-hand, 1/16 in. shoulders.
- Then you can raise the blade for the 5/16 in deep shoulder, make the left-hand cuts and again reverse the miter gauge angle to make the right-hand cuts.
- I avoid having to change the miter gauge angle, which can lead to inaccuracy, by make use of two gauges prearrange to the same but opposing angles.
- Then I can just interchange miter gauges for either a left or right hand cut.
- I band saw the tenon's haunch by clamping a fence 7/16 in. from the outside of the blade and a stop 7/16 in. behind the blade's cutting edge.
- In advance assembly, pare a 1/16 in. bevel on the end of the tenon, so it's easier to push home in the mortise.
- Sand all In advance frame assembly.
- Since the leg stands off the face of the apron a little less than 1/8 in, the leg's line is distinct from bottom to top and pre sanding is possible.
- Lightly sand with 180 grit paper just enough to dull the edge so it won't cut your finger.

How to assemble the frame

- In advance assembly, scrape and sand the inside of the four legs and the front and bottom of the aprons.
- Don't try to glue the entire frame in one operation or you will have a hard time squaring it.
- Glue the short aprons to two of the legs first, making sure each apron's thickest shoulder is on the outside of the leg.
- Apply glue sparingly only to the outside curves of the mortise and on the front part of the tenon cheeks; there's no need to put any on the end of the tenon.
- As you press the parts together by hand, the glue will spread equally on the tenon cheeks and the sides of the mortise.
- If the tenon must be forced, pare off any burnished high spots.
- You need only one clamp with pads, set parallel to the apron, to hold the assembly together.
- The frame must be square in order for the table's four legs to be flat on the floor at the same time.
- Confirm for squareness with the bevel gauge, previously set to the inside angle amongst the leg and apron, and a framing square, for the 90 degree outside angle.
- If the frame isn't square, adjust the direction of the clamp's pressure by to some extent moving one or both of it's ends.
- In advance setting the glued subassemblies aside to dry, confirm that the legs are parallel and the outside diagonals are equal.
- After the glue is set in the subassemblies, complete the frame by gluing the subassemblies to the long aprons.
- Again, you only need one clamp per side, but you may need one across the top to adjust the frame square as you look at it from above.
- Reconfirm d-rat the legs are parallel and their diagonals, as well as those of the top, are equal.
- In advance you fasten the top in place, block-plane or belt-sand the tops of the legs, if they extend above the aprons.
- If you plane them, pare the inside top curves away so they don't tear out as you plane in from the outer edges of the frame.
- Lastly, glue the cleats to the inside and the top of the aprons.

How to finish fastening the top

- Since the edges of the cherry plywood table top aren't eye-catching, you can cover them with cherry edge facings.
- Dry-clamp the four facing pieces to the outside of the plywood, to ensure that the mitered ends fit well.
- Eliminate two opposite pieces, apply glue to their joining surfaces, but not to the miters, and clamp them to the plywood's edges until the glue sets.
- Then, eliminate the other two facing pieces, apply glue to all their joining surfaces including the miters and glue them in place, firmly, aligning the miters.
- If you want to avoid miters, you can butt-joint the facings as flush with the top and bottom plywood surfaces.
- Use a modest router modification; fasten one end of a piece of $\frac{3}{4}$ in. plywood, about 6 in wide by 12 in. long, to the router base so that its edge is set back about $\frac{1}{2}$ in from a $\frac{1}{2}$ in. dia straight bit.
- Adjust the bit's flat end flush with or to some extent recessed from the plywood base.
- When you guide the router around the surfaces, the bit will flush-trim the excess facing.
- Finish sand so the cherry lacing seems as one with the cherry plywood.
- All surfaces are sanded to eliminate machining marks and two coats of Danish Oil Finish.
- Lastly, attach the frame to the top with two #6 by 1 in flat-head wood screws through each cleat.
- Since the screws penetrate only $\frac{1}{4}$ in into the top, a small diameter screw with more threads per inch holds best.
- Lay the top, completed-side down, on a soft blanket and centre the frame on its underside.
- Be cautious not to countersink the heads when boring for or driving the screws or the screw point might penetrate the table top's completed surface.

Chapter 2 – How to make a Dining Table

Optimum comfort definitely applies to chairs, and the same holds true for dining tables. When building a dining table, I start by finding out how the owner likes to dine and where the table is going.

I make use of this information to come up with rough sketches and scale models, which convey material and proportions better than drawings.

Then I measure all-people, dining room, rugs, existing furniture and china-so I can translate dimensions to drawings and occasional mock-ups. This multi-step procedure almost always leads to a table that best suits the client.

How a dining table relates to its users is just as vital as how it relates to its surroundings. The best tables are the ones that make tiny compromises.

Consider, when building a table for a family with children, the resilience of the finish on the table top outweighs the need of the finish to be authentic to the table's style period.

Fortunately, there are some modest guidelines that will benefit with design decisions. The first step is to determine the number of people to be seated, so you can figure the table size that will fit them comfortably.

If the owner entertains regularly, you'll want to make a table with an expanding top that doesn't require a complex leaf system or a forest of legs.

I consult a number of references to get ideas for seating needs. They are only a starting point.

General rules may have to be increased or decreased to take into account the type of table, the space required for the chairs or how else the table might be used.

Basic dimensions

- I've found that the most comfortable height of a dining table is amongst 28 in. and 28½ in, which is a bit lower than what textbooks say.
- But for a family, that height is more informal and makes the sitters feel relaxed.
- The height, of course, depends on the chairs and whether the table has an apron that will bound leg clearance.
- The width and shape of a dining table's top also affect seating arrangement.
- Most chairs are 20 in. wide or so, but you will need better than 24 in. of place-setting width for most people and even more if you're dealing with squirming youths.
- For the minimum overall width of the table, I make use of 36 in.
- A table much over 40 in. wide will lose any feeling of intimacy amongst eaters on opposite sides.
- An oval top offers more side seating than a rectangular top of similar square footage.
- It's easier to squeeze two more people in the ends of an oval when company comes over.
- But since square and round tables take up less space, they frequently fit better in small dining areas.

How to measure everything

- Once you have figured out the seating and overall table size, take out a tape measure, and sit at a comfortable dining table and think about the relationships of sitter to chair to table.
- Then start thinking real life dimensions.
- With the biggest sitter at a relaxed, seated position, measure the distance amongst his or her elbows and knees.
- Measure knee heights, and add a little extra to establish the bottom of the apron height.
- Measure how far forward the person likes to put his or her feet.
- Measure dinner plates, serving platters and the room where the table is going.
- Exact dimensions aren't as vital as how they all relate.
- Once you get the final shop drawings, you will already have a good idea of how the table will look, and consequently, how it will match the room and furnishings that surround it.
- Most styles of furniture offer variations for dining tables, such as top shapes, woods to make use of and options for bases.
- It's worth looking at lots of examples of the period you're working in since you may have to do some hybrid designing to come up with a table that matches a sideboard or china hutch.
- Similarly, if you're making a contemporary table, it's useful to know the tastes of your client since you're likely to borrow the lines or elements of his or her favourite furniture pieces.
- When I build quarter-scale table models, I make numerous variations to benefit the customer visualize differences in proportions and supplies.
- I make use of various woods to show what colour, figure and grain patterns will look like in the room.
- Alternative shapes for the top, such as free-form edges and book-matched halves, are another example of what models can depict.
- Models can also present a diversity of base forms, which show how much room there will be under the top and how stable the footprint will be.
- The following are the four most common base versions I use.

Single Pedestal

- In terms of stability and looks, the mahogany model typically shows the relative proportions a single pedestal table should have.
- An oval top resting on a single pedestal base is perhaps my favourite dining table, partly since it allows for extra sitters.
- Since this type of table has a central column, it makes sense to have an even number of people on each side.
- An odd number can cramp the person sitting in the middle.
- Single pedestals also lend themselves well to a round top, but there is a size bound that the pedestal will support.
- I bound round tops to 54 in. dia., unless the undercarriage is quite heavy.
- A rectangular top on a pedestal shouldn't be much over 72 in. long.

Double pedestal

- A double-pedestal table will fit an odd number of sitters per side staggered around the columns.
- The top's to some extent asymmetrical shape, which widens in places, essentially offers extra knee space where the curved vertical members are.
- The two pedestals spread out the centre of gravity, so the table can be quite long.
- Double-pedestal tables are good for expansion because the place settings will be in the right spots.

Trestle tables

- Trestle tables are great for accommodating many people because there are lots of expandable-top options.
- Even without leaves, a trestle table can be long as the distance mainly depends on the strength of the stretcher and how far the top boards can span.
- In the case of the trestle model, the book matched cherry top has butterfly keys joining two large boards, similar to classic Nakashima tables.
- Trestle tables also have the base uprights fashioned inward at knee level to accommodate sitters at the ends of each side.
- There are two major drawbacks of a trestle table; first, it requires lots of overhang, compared to a leg-and-rail table, at each end to give enough room for end sitters.
- To allow for this, pull a chair up to the edge of a dining table and measure how far in the ends are.
- I generally allow 16 in. as a minimum amount of overhang all around the table top.
- Second, the trestle's feet interfere with people seated at the ends of each side.

Leg and rail tables

- Leg and rail tables can be robust, as well as quick and economical to build.
- But since a table's legs can take up much of the sitter's leg room, I give each sitter at least 28 in. of width for comfort because about 3 in. is lost around each post.
- Or a leg-and-apron table can be fitted with a bow-sided top, and the legs spread out to the curves to provide more seating room.
- I typically build leg-and-rail tables to somewhat higher - about 29 in. to allow enough leg clearance since the apron will take up some height.
- To do this, determine the bottom of the apron height by measuring the largest sitter in a chair.
- Chairs are typically 17½ to 18 in. high at the seat.
- Allowing 6 to 7 in. for the thighs to go under the top, the bottom of the apron should typically be 24½ to 25 in. above the floor.

Proportion of supplies

- Proportions are such a vital part of overall design.
- I have found that one-quarter scale drawings and models bring up the design issues and questions that I need to present to the customer.
- But to work out final building particulars and to develop templates, I typically make full-scale drawings.
- I then make use of the templates to shape the parts.
- There are benefits to make use of solid wood for the whole table, including the top.
- For me, the resilience variation in grain and smooth transition of top to edge make solid-wood tops worth the effort.
- Though veneered tops may be stable and show consistent pattern and colour, there are ways of achieving similar results in solid wood.
- For stability, I make use of only well-seasoned stock.
- To keep the boards flat, I rough-mill in numerous sessions over two weeks to acclimate the wood to my shop.
- The best way I've found to keep consistent grain and figure patterns is by make use of the widest boards obtainable.
- Wide boards are typically much easier to match than narrow ones.
- For colour continuity, I like the logs that are to be cut into table top stock to be sawn clear through.
- If this isn't practical, choose boards from the same lot, and buy all your wood at the same time.
- Then when gluing up the top, go for the best grain match rather than trying to orient all the end grain a certain way.
- Changes in top thickness as small as 1/16 in. can have a intense effect on how we perceive the table as a whole.
- My tops vary from 1 to 1½ in. thick.
- I allow extra thickness for planing the wood a few times in advance matching up the boards for glue-up.
- Longer boards will likely be cupped or twisted, so give yourself enough wood rather than under-sizing the top's thickness just to get it flat.
- When connecting the top to its base, allow for seasonal movement

by make use of screws in slotted holes or cabinetmaker's buttons.

Chapter 3 – How to make an open pedestal Table

The open framework that supports the elliptical table has a light and airy look that belies its strength. Doubled members that form the feet and table top rails, decrease overall mass, add interesting detail and simplify joining the legs to the feet and rails.

In addition to the elementary joinery, I make use of some template-shaping tricks to greatly simplify building. An elliptical top, with gently curved edges, can be fashioned and edge-molded with a template guided router.

The many duplicate parts of the base were all rapidly and simply cut on a spindle shaper make use of a template that rides in contradiction of a special fence.

How to work with a template

- Templates are particularly useful for speedier and more accurate small production runs.
- I added extra distance to the templates for tenons and for fixing the templates to the stock while machining.
- Templates that are to some extent long are safer to make use of Since they begin rubbing in contradiction of the guide bearing or fence In advance the stock hits the cutter.
- Any errors in the templates will be re-developing in every cut part, so it's worth some extra time to be sure that the templates are perfect.
- From the full-sized front and side elevations of the table's base, I typically make templates for each part from ¼ in. thick medium-density fiber board aka MDF.
- I also made a quarter-arc template of an ellipse for cutting and shaping the top.
- I allowed the template to extend to some extent beyond the quarter of an ellipse limits and outside the true circumference.
- That eliminates the possibility of the router cutting a depression where one quarter meets another when moving the template to shape the four quarters of the top.
- I've also found templates helpful for selecting stock and laying out

the cuts.

- I juggled the templates around to find the most satisfying grain configuration and economical make use of timber in advance cutting out the blanks of American walnut.
- Then I surface and thicknesses the blanks for shaping.
- I also machine the boards for the top, so they could settle in advance re-machining.
- When shaping large pieces, I prefer to make use of a hefty, hand-held router guided by a collar or bearing.
- But for pieces, small enough to handle comfortably, I prefer a spindle shaper.
- For bigger table, arbor and cutters of a shaper develop a smooth, clean cut.
- A shaper fitted with an ordinary pair of straight-edged steel cutters and a shop made ring fence works great for template shaping.
- A different fence is required for each diameter cutter used.
- I make my ring fences from birch plywood with an arc to match the cutter's diameter and infeed and outfeed areas.
- The infeed and outfeed areas make shaping safer since the template can be registered in contradiction of the fence, and the stock is supported In advance it reaches the cutter.
- I set the height of the ring fence with plywood spacers of varying thickness.
- The templates are screwed to the blanks in areas that are cut off later.
- With the machine set perfectly and the waste to be eliminated at a minimum, the operation is safe and pleasant.
- After the joints were cut, I mold gentle curves on all the show edges with the shaper, and leave the edges square at the leg intersections.

How to cut the joints

- Typically, I cut my joints In advance shaping a piece, so I can lay out from flat and square faces.
- But you can also make use of a base framework if is band sawn from large slabs and template-fashioned to conserve timber.
- The only pieces that had straight reference edges were the top rails.
- For laying out joinery on the feet, you can establish a reference surface by extending a straightedge from the flat floor-contact area of the foot to the joint area.
- A block amongst the straightedge and the foot's curved section can be kept the straightedge situated while you mark the joint lines with a try square.
- The first joints you can cut were the tenons of the short feet and their mortises in the long feet, make use of the full-sized drawings to determine joint positions.
- The tenons on the short feet and side rails are wedged.
- I leave them about 1/16 in. shy of the full thickness of the long foot and center rail to allow for any possible shrinkage in the thickness of the mortised members.
- The mortises are cut with a square, hollow-chisel mortiser, and I relieved the sides of the mortises at the back with a chisel to allow for the expansion of the wedges.
- To mark the tenons at the bottom of the four legs, I clamp each leg amongst its correcting feet and scribed the curved shoulder line on each side of each leg.
- I hog off the tenon waste on the radial-arm saw and cleaned up the tenon surface with a shoulder plane.
- The convex curves of the shoulders were pared with a chisel.
- I dry-assembled and clamped the legs and feet to mark the tenons at the upper ends of the legs.
- The shoulders were scribed and the tenons cut as In advance.
- At this stage, I mark and cut one joint at a time and assembled and clamp it together while I mark the after joint.
- Assembling a venture one step at a time seems the only way to proceed in custom work involving curved shapes.

- In fact, this is the way I approach most of my cabinet work.
- Still, I've found it necessary to make small adjustments to the top joints at final assembly after the bottom joints are glued.

How to assemble

- To simplify assembly, I glue up the base into two units, each consisting of a long foot, a pair of short feet and a leg.
- Clamping fashioned work calls for some inventiveness but I find it is this sort of challenge that makes woodworking interesting.
- I overcame the issue of clamping the short feet to the long foot by adding blocks to the outside faces of the short feet.
- These blocks provide a bearing surface for clamps to pull the front together.
- A softwood block amongst the pair of short feet holds the feet at the correct spacing.
- I glued abrasive to the blocks on the outside of the feet to prevent slipping when the joint is clamped.
- I confirmed this assembly dry and pulled the point apart with the short feet still clamped together with their spacing block.
- Then I glued the mortises and re-inserted the tenons.
- The two main clamps were tightened, all confirmed for alignment and the wedges driven home.
- I cut the wedges flush with the ends of the tenons.
- The same clamping arrangement was used to glue the side rails and the supplementary side rails into the long rails.
- I confirmed the accuracy of the shoulder lines of the legs to the feet and made fine adjustments to the tops of the feet make use of a scraper rather than trying to alter the shoulders themselves.
- To clamp the leg in place while glue-up, I screwed through a block spanning the bottom of the feet and into the end of the leg to pull the shoulder tight to the top of the foot.
- The upper part of the frame was fairly straightforward; it glues into two half-assemblies consisting of one center rail, a pair of side rails and two supplementary rails.
- One of the half-assemblies was glued and clamped in place to three of the legs.
- Filler pieces, their lower edges already veneered with walnut, were then glued and screwed in place to form tight-fitting mortises at the tops of the legs.
- The second half assembly was then glued in place.

- Apart from making the four floor pads, the only enduring work on the frame was shaping and drilling the four walnut blocks that attach the top.
- These blocks, which fit amongst the ends of the paired rails, are screwed, counter bored and plugged on the underside of the table top.
- The blocks are held to the rails with $\frac{1}{2}$ in. dia. ebony pegs.
- The holes in the blocks amongst the short rails are elongated to allow the top to expand and contract.

How to glue up the top

- I hand planed the edges for the modest butt joints I used to glue up the top.
- Two particulars are worth mentioning when hand planing or shooting a joint: controlling the plane and confirming for square.
- To control the cut, the left hand does not hold the plane's fore knob but grips the plane's side near the front with thumb on top and index finger rubbing in contradiction of the side of the wood being jointed.
- The rubbing finger provides the control required to move the plane either left or right to adjust the squareness of the cut.
- When confirming for squareness, the square should be held with its body on the planed edge and the blade extended down the face of the timber.
- The angle amongst the long blade and the face exaggerates error, making inaccuracies obvious.
- I glued up the top with the hardwood facing up to avoid any exposed sapwood on the table top
- That way, any cupping would be curved on the upper surface and easier to restrain than a concave top.
- After edge-gluing the timbers, I cut the completed slab to a rough elliptical shape and hand planed it flat, planing first across the grain and then along the grain.
- I cut the slab to a true ellipse with a straight, two-flute router bit make use of the ellipse template and a collar-guided router.
- I couldn't find a stock router bit to cut the gentle curve I wanted on the top's edge, and I didn't want to wrestle the head, top across the spindle shaper.
- So I reground a straight router bit and worked the lower part of the curve first with the top upside down.
- Then I reground the cutter to somewhat more pronounced curve in advance turning the top over to work the upper part of the curve.
- I completed off this asymmetrical scotia shape by fairing the two cuts together with a curved scraper, continuously referring to a template to keep the edge uniform.

How to finish up

- I gave the under frame a couple of coats of linseed oil and polished it off with three coats of dark wax.
- Since the top receives more abuse, I applied numerous coats of a mix of linseed oil, polyurethane and mineral spirits as a base for 14 coats of hand-rubbed, hot, raw linseed oil applied over a month.
- The client then continued the finishing procedure by applying a coat each month for the after 12 months.

Chapter 4 – How to build a Card Table

Card Table with tapered legs and string inlay, are frequently attributed to the 18th-century furniture designer George Hepplewhite, but research suggests that this association may not be exclusively accurate.

I made a similar table from cherry, with crotch mahogany veneer on the aprons. The legs require 6 bd. ft of 8/4 stock, which is enough for the table's four legs plus one extra for confirming the tool setups for the many machining operations involved with the inlays.

The top requires 11 bd. ft. of well-matched 4/4 stock. You'll also need a supplementary 2 bd, ft. of 4/4 cherry for the back apron, which is essentially a three-part building that embraces an inner apron dovetailed into the side aprons and the two-part knuckle-joint gate-leg mechanism that supports the hinged top when open.

The cherry apron beads can be made from leg or top scraps. The front and side aprons are stack-laminated poplar, band sawn to shape and then veneered. I used about 10 bd. ft of $\frac{3}{4}$ in. thick poplar for the laminated blanks.

Since of the curved aprons and the intricacies of the inlays, the first step in building this table is to make full-scale drawings to work out the particulars in actual size.

You'll need patterns for the curved parts anyway, and so you might as well prepare them ahead of time. In addition, if you buy the oval flower inlays and the banding that trims the lower leg as I did, you should have them on hand In advance beginning the venture.

I got my inlays traditionally made from holly, maple or satinwood. I had a piece of 4/4 satinwood, which I sawed into 1/16 -in. wide inlay strips.

Legs, banding and stringing

- Begin by ripping the five 1 11/6 in. sq. leg blanks from the 8/4 stock.
- Crosscut the blanks to completed Distance, and then taper each side make use of a jig that holds the leg at a slight angle as it's passed through the table saw.
- The taper begins 4 in. below the top of each leg and extends to its base, which is only 5/8 in. sq.
- After tapering, each leg requires five separate operations to cut the grooves for the inlays.
- The legs must also be mortised to receive the apron tenons and dadoed for the lower apron bead that runs across the legs, but it's best to do these operations after constructing and veneering the aprons to ensure these joints are located properly.
- You should cut the banding grooves around the bottom of the legs first as they make handy stops for the long stringing grooves that you will cut afterward.
- This bit of wisdom comes from hindsight; I cut the stringing grooves first.
- I routed the banding grooves on the tapered legs with the aid of a miter gauge, even though the router table had no miter gauge slot;
- I simply ran the gauge's bar along the table's front edge with the router table fence clamped parallel to the front edge to locate the grooves.
- I set the miter gauge angle to compensate for the legs' taper by making test cuts on the fifth leg and measuring up squarely from the bottom of the leg until the groove ran parallel to the bottom.
- I made the long, straight grooves for the stringing with a Dremel tool fitted with a router-base attachment and guide.
- To cut the 3/4 in-radius grooves at the top of the stringing pattern, I made a 1/8 in. thick Plexiglas fixture that has a 1/8 in. dia. hole in the centre of each of the arcs.
- A pivot pin screwed through the router-attachment base is inserted into each centre hole in turn and the Dremel tool is pivoted to cut the arcs.
- I used a pair of dividers with a dowel taped to one leg to locate the

fixture on the surface to be inlaid.

- When the fixture was aligned so the arcs began at the ends of the straight stringing grooves and met at the centreline of the leg, I clamped the fixture to the leg and cut the grooves.
- After cutting the banding and stringing grooves, I ripped out the thin satinwood strips.
- When I got around to fitting the curved stringing sections, I discovered that satinwood is too brittle to bend well, and so I had to soak the stringing in water for numerous minutes and then bend it over a hot pipe mounted on a soldering iron.
- The soaking and heating had to be repeated numerous times to achieve the desired bend, and even then I broke numerous pieces.
- I cut and fit all the stringing for one leg surface at a time, including miters at the curves, and then glued the pieces in right away so I wouldn't lose them.
- The stringing expands to somewhat when it absorbs glue; so you should press the pieces into the glue-filled grooves as rapidly as possible.
- The expansion holds the pieces so rightly that there is no need to clamp the stringing.
- After all the stirring is applied, I glued the banding strips into their grooves at the base of the legs.
- In advance inlaying the flowers, I sanded the stringing and banding flush then made use of 100-grit paper on a sanding block.

Flower inlays

- My table required eight sets of satinwood bell flowers.
- Each set has four flowers that diminish in size from top to bottom, and so I required 32 flowers in all.
- To streamline the procedure of cutting out the flowers, I glued up a stack of nine pieces of satinwood veneer with a piece of paper amongst each layer so the stack could be simply separated later.
- The ninth layer gave me an extra set of flowers just in case.
- After cutting out the flowers with a scroll saw, I sanded and filed each stack to final shape and then inserted a sharp knife, but you could also make use of a razor blade on the paper glue line to pop the veneer layers apart.
- Inlaying the 32 separate flowers isn't hard, but it is slow work.
- It's not something you can whip out in a couple of hours; so realize up front that you have to take your time.
- To begin, place one of the large flowers carefully on the centreline of the leg and trace around it with a sharp pencil; do one flower at a time.
- I use my Dremel tool with a router base to clear out most of the wood, and then I clean out the tight curves and final fit each flower with a knife and a small chisel.
- For both the routing and the final fitting, I use a lighted magnifying glass - the kind that clamps to a table top and that jewellers frequently use.
- I've found that if I'm satisfied with the way an inlay looks through the magnifying glass, it really looks great without magnification.
- Fit one flower at a time and then glue it in place with a clamp and waxed-paper-covered block.
- By the time you've inlaid one flower on each leg, the first leg will be dry enough to unclamp so you can inlay it's after flower.
- The six oval inlays at the top of the legs are fitted the same way as the flowers.
- After all the inlaying is complete, finish-sand the legs through 220-grit.
- Ensure that all traces of dried glue have been sanded away.
- I thought I had done a thorough sanding job, but when I sprayed

on the first coat of lacquer, numerous glue smears showed up and I had to re-sand all of these areas.

- You can locate dried glue in advance finishing by wetting the wood's surface with water: glue residue will show up as light-colored areas.

Veneered front and side aprons

- The front and side apron blanks are made by stack laminating $\frac{3}{4}$ in. thick yellow poplar to the following sizes: one $3\frac{1}{2} \times 4\frac{1}{2} \times 21\frac{1}{2}$ front apron; and two $3\frac{1}{2} \times 3\frac{1}{2} \times 15$ side aprons.
- Use the gridded drawings of the front and side aprons to make full-size templates for laying out the curves on each blank.
- When you band saw the curves keep the cuts as clean as possible, Since the waste part of each apron will be used to clamp the veneer to the apron.
- Sand or scrape out any slight irregularities in the apron curve, and then screw temporary blocks to each end of the waste portion of the apron blank to ensure perfect alignment when clamping the veneer.
- I recommend make use of backed veneer if you can find it as it is much easier to handle than single-ply crotch mahogany.
- I bought book-matched crotch mahogany veneer backed with poplar veneer.
- Cut the veneer so it overhangs about $\frac{1}{4}$ in. on both edges of the blank.
- Then glue the veneer to the outer face of the apron, clamp the waste half of the blank over the veneer with C-clamps and let it dry overnight.
- The next day, unclamp the aprons and trim the overhanging veneer with a sharp knife.
- The ends of each side apron must be trimmed to distance at a 58 degree angle from the straight rack side.
- Since of the hardy of cutting tenons on these angled ends, the side aprons are doveled into the front legs.
- In addition, a notch must be cut at the back end of each side apron to square off an area to receive the dovetailed rear apron.
- Make the 58 degree parallel end cuts make use of the miter gauge on the table saw and with the blade tilted 32 degree from its usual 90 degree position.
- Then lower the blade and make the 58 degree cut on the inner face of the side apron to form the notch that will house the rear apron.
- Return the blade to its square position and complete the notch by standing the apron on its back end and supporting it with the miter

gauge.

- After notching both side aprons, raise the blade and trim the front ends of both side aprons in a similar manner, with the aprons standing on their front ends, to form a flat area to join with the glue blocks.
- The tenons that join the front apron to the legs must be cut in two steps as of the curve on the aprons face.
- Trim the apron to distance first, allowing for the $\frac{3}{4}$ in. long tenons.
- Then, on the table saw, cut the tenon shoulder and cheek on the aprons back side with its flat side down.
- The apron can't be flipped over and run facedown as of the curve and so the top shoulder and cheek must be cut from above with the radial-arm saw.
- I made the tenons $\frac{5}{16}$ in. thick and centered them on the apron's squared-off ends.
- When locating the mortises and the dowel holes in the front legs, keep in mind that the aprons are set back $\frac{1}{8}$ in. from the corner of those legs.
- I bored the $\frac{1}{2}$ in. dia. dowel holes in the front ends of the side aprons on the drill press by clamping a wood hand screw to the back end of the apron to provide a „foot" to stand it up vertically on the drill-press table.
- Then I used another hand screw as a leg to support the upper portion of the angled apron I inserted commercial dowel centres into the holes to locate the mating holes in the legs.
- To complete the front legs, locate and cut $\frac{5}{32}$ in. wide by $\frac{3}{16}$ in. deep dadoes on the outside surfaces of each leg to receive the bead that runs around the bottom of the aprons.

Rear aprons

- The three-part rear apron consists of a long inner apron dovetailed to the side aprons, and two short aprons that are tenoned into the rear legs and joined at the middle with a knuckle joint, or wooden hinge.
- The apron that's joined to the fixed rear leg is screwed and glued to the long dovetailed apron, while the other is tenoned to the gate leg and allowed to pivot to support the table top when the flap top is open.
- To determine the distance of the dovetailed apron, dry-assemble the front legs with the front and side aprons, and then while holding the joints together firmly, measure the exact distance amongst the notches in the back ends of the side aprons; don't forget to add the distance of the dovetails.
- When making the two-part outer rear apron, don't cut the parts to exact distance; leave each about 2 in. too long until after you've cut and fit the hinge.
- There's no reason to be scared by the idea of making a wooden hinge.
- Simply lay out the interlocking fingers directly on both hinge parts and mark the areas to be cut.
- Set the table saw blade at the same height as the thickness of the parts, and while holding the work piece vertically and supported by the miter gauge, make repeated cuts to eliminate the waste.
- In advance rounding over the curves to form the knuckles put the two parts of the hinge together and make use of the drill press to bore the $\frac{1}{4}$ in. dia hole for the steel hinge pin.
- Drill clear through the hinge assembly so you can simply eliminate the pin when trial-fitting.
- You'll trap the pin at final assembly by gluing a dowel plug in the bottom of the hole.
- After drilling the hole, take the hinge apart and make use of a disc or edge sander to round over the curves that form the hinge's barrel; replace the pin and ensure the gate-leg apron swings through 90 degree, even when the fixed apron is held firmly to the dovetailed rear apron.

- When the hinge is complete, cut both parts of the hinged apron to distance, allowing $\frac{3}{4}$ in at each end for the leg tenons.
- Instead of centering the rear leg tenons as on the front apron, I made them flush with the back surface of the aprons to give the mortise a bigger setback in the gate leg.
- Lastly, locate and cut a mortise in each rear leg so that the hinged apron's inside face is flush with the face of the leg.
- The front and side aprons can now be finish-sanded to 220-grit in preparation for assembly.
- Nevertheless, In advance gluing up the table base, make use of the front and side aprons as patterns for band sawing the $\frac{5}{32}$ in. thick cherry that is glued to the bottom of the aprons to form the bead.
- Ensure that the front edges will protrude about $\frac{1}{8}$ in. and round over these edges with a finger plane or small-radius router bit.
- Also, round over some of the scrap from the curved pieces to make the short sections of bead for the legs.

Gluing up the base and attaching the top

- Since of the unusual building of the base, I glued it up in numerous steps.
- First, I glued the two hinged aprons to the rear legs and the side aprons to the front legs.
- In order to clamp the side aprons, I had to screw blocks to the inside of the aprons temporarily.
- After the side apron front leg assemblies were dry I glued the front apron and the dovetailed back apron in place.
- Then I cut, fit and screwed in the corner glue blocks.
- Afterward, I glued and screwed the fixed rear apron/leg assembly to the dovetailed apron and attached the gate-leg assembly by inserting the hinge pin into the knuckle joint, after plugging the bottom of the hole with a short dowel.
- Lastly, I glued the apron beads in place, and fitted the small leg beads into the dadoes and glued them in place.
- I used metal clips to secure my table top to the aprons.
- These table top fasteners, which hold the solid top to the aprons while still allowing it to expand or contract, are obtainable from most woodworking companies and in some hardware stores.
- With the table standing on all four legs, it's easy to rout the slots with a 1/16 in.-wide, winged slot-cutting bit; of course, you need to buy the clips first so you know how far the slots should be from the upper edge of the aprons.
- Building of the two-part table top is very straightforward.
- The 4/4 stock is planed 13/16 in. thick and then glued up to make two pieces about 20 in. wide by 37 in. long.
- When these top blanks are dry, the glue squeeze-out is scraped from the joints and the mating (hinged) edge of each blank is cleaned up on the jointer.
- Then apply double-faced tape to the surface of one blank, and place the other blank on top, taking great care to perfectly align the mating edges.
- The top's shape is then drawn on the upper surface from a full-scale pattern and both pieces are band sawn out at the same time with the two table top halves still stuck together, sand the sawn

edges to completed shape.

- Then you can separate the two halves and make use of a router with a $\frac{1}{4}$ in.-radius bit to round over the inside mating edge of both top pieces to provide clearance when the top is opened and closed.
- I bought my card-table hinges and I had to grind down a $\frac{1}{2}$ in wide high-speed steel router bit to cut the $\frac{15}{32}$ in. wide mortises in the edges of the table tops to receive the hinge leaves.
- I recommend that you make use of steel screws for fitting the hinges initially and then replace them with brass screws at final assembly.
- At this point, you can place the assembled top on the base, screw the table top fasteners to its underside and confirm that the top and gate leg both open and close as they should.
- Lastly, disassemble the table top from the base and the hinges from the tops and apply the finish.
- I used spray lacquer, rubbing amongst coats with 400-grit paper and smoothing the final coat with 0000 steel wool to develop a satin sheen.

Chapter 5 How to build a tea cart

A tea cart isn't as essential as a table and chairs in a dining room, but it's always been very popular choice for shoppers. People are fascinated by the cart's mobility and intrigued by the possibility of simplifying the daily task of setting and clearing a table.

Tea cart is lightweight, but robust, and the large diameter of its wheels enables it to pass simply over thresholds and carpets. The cart itself is basically a small table with both legs at one end cut off just below the cross rung.

The steel axle, which is housed within the cross rung, does not rotate. Instead, each hub is fitted with a pair of shop made brass bushings that turn very smoothly on the axle.

While I steam-bend the wheel rims when working with woods that bend well, like oak, ash or walnut, rims can also be made by laminating thin strips together around a circular form.

The bent rim stock is wrapped around the spokes, screws are run through it into the ends of the spokes and the screw holes are then plugged. The loose ends of the rim are band sawn at an angle and glued together in a long scarf joint to close the wheel's circumference.

In advance building the tea cart, you might want to contemplate a few options that can add to the utility of the basic cart. A shallow drawer can be installed below the handle by screwing guides to the side rails and reducing the width of the back rail to accommodate the drawer front.

If you want more surface area than the tray provides, a lower shelf can be added by gluing cleats to the side rungs to support it. I recommend ¼ in. thick tempered glass for this lower shelf as a wood shelf makes the cart look too heavy. Another option is lining a portion of the trays surface with ceramic tile.

Looking at the cart Joinery

- The cart's frame consists of four tapered legs, four upper rails that form the trays sides and ends, four lower rungs and the handle.
- For the oak cart, I began with $\frac{3}{4}$ in. stock, ripping and crosscutting the rails and rungs to size and planing them.
- The front rung is to some extent denser than the other rungs to accommodate the axle.
- You'll need a 7-in by 30-in. piece of $\frac{6}{4}$ stock for the handle and legs.
- Even though the front legs will ultimately be cut off just below the front rung, you should make four full-distance legs so you can taper them all on the same table saw jig.
- If you cut the legs from a 7-in. wide board and reverse the stock in the jig after each cut, you'll have enough stock left over for the handle.
- The leg-taper jig will let you rip and plane 30 in. long legs that taper from 1 in. square at the top to $1\frac{1}{4}$ in. square at the bottom.
- To make the jig, begin with a 7x2x32 board and lay out and band saw the taper.
- Fine-tune the tapered surface with a hand plane or jointer and then glue a $\frac{1}{2}$ in. by 1-in. stop on the flat end of the jig.
- To cut the tapered legs, place the jig on edge on the saw table and up in contradiction of the rip fence.
- The fence should be adjusted to leave about $1\frac{1}{8}$ in., amongst the jig and the saw blade just in front of the jig's stop.
- Now, pull the jig back so there's room to lay your leg stock flat on the table in front of the blade with its end in contradiction of the stop and its jointed edge firmly in contradiction of the jig.
- Hold the jig and stock in contradiction of the fence and rip the first leg.
- The operation is repeated with the stock reversed end for end after each pass, until you have four legs tapered on one side.
- Then roll each leg 90 degree and taper all four legs on an adjacent side.
- To clean up the saw marks and to plan the legs to their final size, place them on the jig with the sawn side up and run them through

the planer, stop end first.

- Plane each leg on both adjacent sides until the small end is 1 in. square.
- The two front legs can now be crosscut to 19 in. long.
- Tilt the blade used for crosscutting just a tad so that the end of the leg is cut square with the center line and not just with the tapered side.
- The rails and rungs are joined to the legs with through, wedged tenons all around.
- In addition, the front curves of the tray portion of the rails are also dovetailed together.
- On the first cart I built, I made the side and front rails wide enough to embrace the tray sides, and then I ripped each rail into two pieces even with the top of the legs.
- This made it possible to lay out and cut the tenons on the rails separately from the dovetails on the tray sides.
- Then I edge-glued the rails and tray sides back together in advance gluing up the cart frame.
- This simplified the joinery, but I was unhappy with the visible glue line.
- So now, instead of ripping the rail stock into separate rails and tray sides, I leave the rails their full 4¼ in. width.
- Then, I band saw the rail tenons, handle supports and dovetail pins on the side rails, and finish them up by hand with a chisel.
- While this complicates fitting and cutting both the rail tenons and the tray dovetails, I think it's worth the trouble to preserve the smooth, unbroken surface on the side of the rails.
- Whether you rip the rail/tray sides in advance joinery or attempt the one-piece technique, the mortises for the upper rail tenons are laid out on the two adjacent sides.
- The adjacent mortises are then cut on different sides of the lines so the intersecting tenons will miss each other.
- I initially intended haunch tenons for the side rails to resist any tendency for the rails to twist.
- After building the piece, I decided the haunches weren't necessary as there is enough support with the handle at one end and the dovetails at the other.

- Nevertheless, I still make use of the haunch tenons on the rails as it's easier and faster to chisel a clean shoulder if the haunch endures.
- I make use of a 3/8 -in. dia. end mill in my drill press to cut the mortises.
- A fence clamped to the drill-press table registers the mortises side to side and a feather board holds the pieces firmly in contradiction of the fence.
- I drill overlapping holes to clear out most of the mortise and then slide the piece sideways along the fence to smooth the sides.
- Of course a table-mounted router or a plunge router with templates can also be used for mortising.
- When all the mortises are complete, the tenons are cut to fit them.
- As I mentioned earlier, if the rails and tray sides are left in one piece, the tenons on the side and front rails must be band sawn and fitted by hand.
- The rung tenons and those on the narrow upper rail that runs beneath the tray at the handle end can be cut on the table saw.
- I make use of a small carving gouge that has a 3/8 in. dia. arc to round the tenons to fit the arc of the mortise ends and then individually confirm the fit of each tenon to its mortise.

Joining the tray

- When the rail and rung tenons are done, you can turn your attention to the upper portion of the rails that form the tray sides.
- In advance sawing out the dovetail pins on the front ends of the side rails, I plane a 30 degree bevel on the inside edges.
- This bevel makes a nice detail where the tray sides meet at the front curves and lightens the tray visually, but it is yet another complication for making the dovetails.
- You might want to avoid the dovetails exclusively and miter the tray curves instead.
- If you continue with the dovetails, you will have to vary the pin depth on the side rails to accommodate the 30 degree angle that you will later plane on the front rail.
- First, cut the pins on the side rails, assemble the front rail and front legs, and mark for the tails.
- Then, cut the tails to fit, and bevel the inside of the front rail to match the angle for the pin.
- Now you can rout the $\frac{1}{4}$ in. by $\frac{1}{4}$ in. groove on the inside of the side rails for the tray.
- I make use of $\frac{1}{4}$ in. veneered plywood for the tray, which I slide into the grooves after gluing up the cart frame.
- A narrow cleat is glued to the front rail to support that end of the tray and a strip of hardwood is glued on to cap the back edge.
- The last step in forming the tray sides is to shape the handle extensions.
- First band saw the gentle curve along the top edges of the sides and then band saw the ends of the extensions to receive the handle.
- The ends of the extensions are cut out to wrap partway around the 1 $\frac{1}{8}$ in. dia handle, and a $\frac{3}{8}$ in. by $\frac{1}{2}$ in. tenon protrudes from the extension through the handle and is wedged like the other tenons.
- Turn the handle, but I recommend waiting until the cart frame is glued up in advance marking and drilling the mortises that join the handle to the extensions to ensure that the back of the frame pulls firmly together.
- These mortises are cut on the drill press like the others, except the

round handle is clamped into a V-block to keep it from turning.

- For a single cart, the rungs can be simply fashioned by hand with a spokes have, compass plane or rasp.
- The bottom of the denser front rung is left straight and a 3/8 in. by 3/8 in. slot is routed in it to house the axle.
- Break the edges of the rungs and legs with a 1/8 in. radius round over bit and sand all the parts In advance assembly.
- The axle is a 3/8 in. dia. by 21-in. long cold-rolled-steel rod.
- It extends through the front rung mortises in the legs and is locked in place when these firmly fitting joints are assembled.
- The hubs are secured to the axle with snap rings, which are obtainable at most hardware and auto-parts stores.
- In advance the cart frame is assembled, the axle is cut to distance and its ends are to somewhat beveled and grooved to receive the snap rings.
- In determining precise axle distance, you must contemplate the distance amongst the snap-ring groove and the end of the axle, as well as the hub size, leg thickness and distance amongst the front legs.
- Adjust your axle's distance if any of these critical dimensions vary from.
- To make the snap-ring grooves, I place one end of the axle in a Jacob's chuck mounted on the headstock of my wood lathe and the other end in the shallow cup of the tailstock center with its center point eliminated.
- The cup happens to be just the right diameter for the axle and about 3/32 in. deep.
- This depth seemed to be a good distance from the end for the snap-ring grooves, so I use the rim of the center cup as a guide for cutting the groove with a hacksaw.
- I lubricate the cup with a little grease, and with the lathe turning the axle at low speed, I hold the hacksaw blade in contradiction of the cup's rim and cut about a 1/32 in. deep groove.
- Test the groove to be sure the snap ring fits and then reverse the axle and groove the other end.
- Now, you're ready to glue up the cart frame.
- Assemble the end frames first and then split the end grain of the

tenons with a 3/8 in chisel and drive in a wedge dabbed with glue.

- Glue up the front rung with the axle in place and centered so that the snap-ring grooves are equidistant from the outside faces of both legs.
- Trim and sand the tenons flush with the legs on the end frames, and then glue up the sides and trim and sand those tenons.
- The top ends of the legs now interrupt the groove for the tray, so chisel the grooves through the legs so the plywood tray can slide all the way to the front rail.
- Secure the tray at the front rail by gluing it to the cleat that's also glued to the front rail.

Making the hubs and spokes

- Building the wheels is not as hard as it looks.
- I make the hexagonal hubs first, and then shape the spokes and glue their tenons into the hubs.
- The spokes are then trimmed to distance on the band saw with a circle-cutting fixture.
- Afterward, the narrow wheel rims are steam-bent, wrapped around the spokes and screwed into the end of each spoke.
- To make the hubs, set the table saw blade to 30 degree and rip the curves off a 2 x 2 5/16 x 7 block to form a regular hexagon.
- Locate the centers of both ends and mount d-re block amongst centers on the lathe.
- Turn both hubs from the blank.
- Eliminate the hub stock from the lathe and band saw fie hubs apart.
- Next, a Jacobs chuck with a 1 in dia. Forstner bit is mounted in the headstock of the lathe.
- Now, mount each hub amongst the tailstock center and the center of the Forstner bit.
- With the hub suspended amongst centers, advance the tailstock center with the hand screw and drill a 7/16 in. deep hole in the round end of each hub.
- Then, change bits and drill a 7/16 in. dia. hole all the way through each hub.
- Now, eliminate the hub from the lathe and with a 1/2 in dia. bit in the drill press, enlarge both ends of the 7/16 in deep hole to 3/8 in. deep to accommodate the brass bushings.
- Metal bushings ensure that the cart will roll smoothly for a long time.
- A steel axle with wood bushings just won't do; if the wooden hub expands, it will lock onto the axle, and if the hub shrinks, the wheel will become floppy.
- I make brass bushings by boring a 3/8 in. dia. hole in the center of a 1/2 in. dia, round brass rod.
- To bore out the rod, mount Jacobs chucks on both the headstock and tailstock of the lathe.

- Chuck a 2 in. long piece of brass rod in the headstock chuck and a 3/8 in bit in the tailstock chuck, and then with the rod turning at low speed, slowly advance the tailstock to drill through the rod.
- Then, with the rod still spinning at low speed, saw off 3/8 in. long sections with a hacksaw: two for each hub, four for each cart.
- Epoxy the bushings into the hubs and when the epoxy dries, run a 3/8 in. drill bit through the bushing's center to eliminate any squeeze-out.
- Squeeze-out on the bottom of the 1-in. hole can be cleaned up with the 1-in. Forstner bit.
- While the spokes are ultimately rounded over and fashioned with a hand plane, I start out by tapering then in both thickness and width on the table saw.
- Since the amount of taper is different in each dimension, you'll need two spoke-taper jigs.
- A 1x8x12 board will yield six tapered spoke blanks, so you'll need one board this size for each wheel.
- Begin with the jig that has 3.4 in. deep notch and adjust the rip fence so the blanks are tapered from 3/4 in. at one end to 1 1/2 in. at the other end.
- Rip the individual tapered blanks by reversing the work piece end for end after each cut, just as you did with the legs.
- Afterward, joint one edge of each blank and run this edge down on the saw table – you make use of the jig with the 3/16 in. notch to taper the blank thickness.
- Adjust the fence to taper the spokes from 1 in. to 13/16 in.
- Find the center of both ends of each blank and, one by one mount them amongst centers on the lathe and turn a 1/2 in. dia by 1/2 in. long tenon on the large end of all 12 spokes.
- In advance removing each spoke from the lathe, rough-turn the spoke just to be enough to be sure the tenon will be dead center after the spoke is final fashioned.
- The wide end, with the tenon, is fashioned to a nice oval that tapers smoothly to a 3/4 in. dia. circle at the other end.
- The spokes can be left on the lathe and fashioned with a spoke shave, if the headstock can be locked so it won't turn.
- After shaping and sanding the spokes, they are glued into the hub.

Locate the centers of the flat surfaces on the hub and then drill a $\frac{1}{2}$ in. dia. mortise, $\frac{9}{16}$ in. deep, in each face to receive the spokes' tenons.

- Glue two spokes at a time, spanning both spokes and the hub with a pipe clamp.
- After all six spokes are glued into the hub, I make use of the band saw circle cutting setup to trim them to distance.
- Drill a $\frac{3}{8}$ in. dia hole in a scrap block and, for a 24-in. dia wheel, clamp the block to the band saw table so that the hole's center is $11 \frac{3}{8}$ in. from the blade, measured 90 degree from the blade's cutting line.
- Place a $\frac{3}{8}$ in. dia. drill bit in the scrap block's hole to mount the hub, and clamp a shim near the blade to support the small end of the spokes.
- Then, turn on the band saw and rotate the hub to trim the spokes.

Making the wheel rims

- Oak steam-bends well, and I use steam bent parts in other pieces of furniture that I make on a regular basis, so it was natural for me to make use of this technique for the wheels' rims.
- With woods that don't steam-bend very well, like mahogany or cherry, you could start with to somewhat denser wheel stock, re-saw it into three or four thin strips and laminate them back together over a form.
- Nevertheless, steam-bending has the advantages of no messy edges to clean up and no glue lines.
- I've had good luck steam-bending oak, ash, beech and walnut, in that order.
- No matter which bending technique you use, you'll need a plywood form, the same diameter as the trimmed spokes, to bend the rim stock around.
- The ends of the rim stock must run past each other at least 6 in. on the form to allow for the scarf joint that closes the rim's circumference.
- Instead of doubling up the form to make it wide enough for the ends to run past each other, I make a kind of spiral form.
- I band saw a 2-in. wide, 22 3/4 in. od ring from a scrap of 3/4 in., thick plywood.
- Then, I cut about a 4-in. long section out of this ring and glue quarter sections of another 2-in. wide, 22 3/4 in. dia. ring on opposite sides of the original ring, so that the quarter sections overlap at the gap.
- This forces the original ring into a spring-like shape.
- Now you're ready to steam the rim stock.
- You'll need 7 ft. of clear straight-grain stock, 5/8 in. thick and 3/4 in. wide, for each rim.
- Rip an extra rim strip for each cart you're building in case one breaks when bending.
- I screwed together a 7 ft. long by 5 in. square wooden box, left open both ends, and sawed a 4 in. square hole in the middle of the bottom.
- A row of dowels, inserted from side to side, creates a rack to hold

the part being steamed off the bottom of the box.

- I placed the box on top of an electric fry pan full of water so the steam will enter the box through the 4-in. hole.
- Scrap boards cover the portions of the frying pan that aren't covered by the steam box, making it easy to confirm and replenish the water level when necessary.
- When the water is rapidly boiling, I put the rim stock in the box, plug the ends with cloths to keep most of the steam in and wait about 45 minutes.
- When the pieces are eliminated from the steam box, you must work smoothly and rapidly as the wood cools and dries out, it loses its flexibility.
- Have your form and a couple of C-clamps ready.
- Eliminate the rim stock from the box and clamp one end to the "beginning" of the spiral form.
- Rapidly turn the form so the steamed wood is on the floor, and roll the rim onto the form, pressing firmly on the floor as you go.
- When, you get around to where the clamp hits the floor, pull the free end of the rim stock up by hand and clamp it to the form so it overlaps the first end.
- Now, place another distance of rim stock in the steam box, replenish the water and wait 45 minutes.
- When the second rim is ready to be bent, unclamp the first rim from the form and clamp its overlapping portions side by side to maintain the circle.
- This frees up the form for bending the second rim.
- Repeat the steaming and bending procedure until you have all the rims you need and then let them dry overnight.
- To support the hub-and-spoke assembly while attaching the rim, clamp the axle in a bench vise.
- Then, hold the rim so the scarf joint that closes the circle will fall amongst two spokes and screw the rim to one of the spokes opposite the joint.
- To do this, first bore a 3/8 in. dia. hole about 1/8 in. deep for a wood plug, and then bore a 1/8 in. dia. hole through the rim for a 1 in. long, #6 brass wood-screw shank.
- Lastly, while holding the rim in position in contradiction of the

spoke, bore a 1/16 in. dia pilot hole into the end of the spoke.

- Now that the rim is located on the hub-and-spoke assembly, you can continue around the rim boring holes and screwing the rim to each of the spokes, except the one nearest the rim's joint.
- With this one spoke still unattached, eliminate the wheel from the axle so you can lay out the rim's scarf joint.
- First, let the loose portion of the rim overlap alongside the attached portion and use a C-clamps at both ends of the rim to clamp it into the appropriate arc.
- Afterward, measure 6 in. along the rim's circumference and divide this into four equal 1 ½ in. sections.
- All five lines should now be transferred down the sides of the rims with a square.
- Then, still working on the rim's sides, divide the centreline in half and the lines on the right and left of the centreline in quarters.
- Now, begin at the inside edge of the rim and draw a diagonal across to the outside edge by connecting the appropriate points along the lines.
- Turn the wheel over and draw a similar diagonal on the other side of the rim's overlap.
- After laying out for the scarf joint, eliminate the clamps and band saw close to the diagonal lines: above the line on one overlap and below the line on the other.
- With a rasp, clean up the mating surfaces until they clamp together without a gap and then screw the rim to the last spoke.
- The scarf joint is glued together and clamped with pieces of scrap wood band sawn to the rim's inner and outer arcs to distribute the clamping pressure.
- After the glue is completely dry, scrape and sand the sides of the rim so the joint can't be detected.
- The wheels are now complete except for plugging the screw holes in the rim and some final detailing.
- I bevel the rim's inside edges on the router table with a 45 degree pilot-bearing router bit, taking care not to nick the spokes.
- Then I make use of carving tools and files to shape the transitions where the spokes meet the rim and-hub.
- In advance mounting the wheels on the cart, I finish them and the

assembled cart with numerous coats of Danish oil.

- When the wheels are mounted on the ends of the axle, you should be able to see the snap-ring groove.
- If you can't, eliminate the wheel and drill the 1-in. hole a little deeper.
- You can get a pair of snap-ring pliers at any auto-parts store.
- The tool is simply a $\frac{3}{4}$ in. square distance of hardwood with an axle-size, $\frac{3}{8}$ in. dia. hole drilled in one end.
- To mount the wheels, lay the cart on one side, place the wheel on the axle and balance a snap ring on the axle's to some extent beveled end.
- Then, make use of the tool to press the snap ring onto the axle until it fits in the groove.
- Turn the cart over and mount the other wheel the same way.
- To cover the axle and cap the hubs, I turn tapered plugs to fit in the 1-in. holes and then drill at $\frac{5}{8}$ in. hole, about $\frac{1}{4}$ in. deep, in one end to make room for the axle.

Chapter 6 How to make a breakfast table

A drop-leaf table, narrow when closed, would fit the space and provide terms for a truce in my little battle. And as a peace dividend, I could always open up the table and use it elsewhere for special occasions.

The small table I made is a good example of a breakfast table. The 18th century form combines grace and versatility and making it demands the same attributes in the craftsman.

The half-blind dovetailed aprons, rule-jointed leaves and the knuckle joints on the swing leg: all require precise work. And shaping the compound curves of the cabriole legs needs a steady hand and eye.

The skills are not hard to master, and the effort will be rewarded with a useful and elegant table. The original on which my table is based was made of walnut, but I built mine of cherry.

Maple or mahogany would also be appropriate. I used pine for the small amount of secondary wood.

Where to begin

- Begin the table by milling the required material.
- Leave the leg billets to some extent oversized, and set them aside for a few days so any movement can later be planed out.
- The pieces that will form the side aprons should be left a few inches over completed distance at this point.
- The extra distance will allow you to recut the knuckle joint for the hinge of the swing leg if necessary.
- Cut the fixed top and the leaves from the same board, so color and figure will be consistent.

The knuckle joints

- The knuckle joints are at the heart of the table, and I start with them.
- The joint and the aprons it connects must be accurately aligned to ensure the fly leg stands vertically both in its home position,

where it must meet the end apron squarely, and in its open position, where it must support the leaf at just the height of the fixed top.

- A knuckle joint is basically a finger joint with it's fingers rounded over and the bottoms of its sockets coved.
- To provide a positive stop for the swing leg at 90 degree, the joint has mating 45 degree chamfers on both aprons.
- The knuckles can be cut on the table saw with a finger-joint jig and then completed with hand tools.
- With only two joints to cut, though, I opted to make the entire joint with hand tools.
- Cutting and fitting the joint is not hard, but accurate layout is essential to success.
- Begin the layout by marking in from the end of each piece by the thickness of the material.
- Then carry a line around the apron at that point.
- Draw diagonal lines in the square you've created on the top and bottom edges of the stock, and draw a circle.
- The short section of the diagonals amongst the circle and the original layout line is the chamfer line.
- To make chamfering easier and more accurate, you'll need a relief cut.
- Draw a line parallel to the first layout line, and score along it with the corner of a sharp chisel guided by a square.
- Then chisel a shallow V-groove on the side of the line nearest the end of the board.
- The groove provides a channel for your saw to ride in as you start the relief cut.
- Make the relief cut with a tenon saw or dovetail saw, stopping just as the kerf touches the circle laid out on the edge of the board.
- Now make a guide block beveled at 45 degree, and ride a rabbet plane on the bevel to cut the chamfers.
- Shape the barrels of the hinge with chisels and a block plane.
- Refer to the circles on each edge of the board as you proceed.
- Begin the rounding by planing a series of facets from end to end.
- Continue cutting narrower facets until the barrel is round.
- You could also make use of a router for some of the rounding

over.

- A piece of scrap wood can be coved to the same radius as the barrel and used as a sanding block for final smoothing.
- Lay out and cut the sockets amongst the knuckles Afterward.
- Divide the board into five equal units across its width, and extend the division lines around the barrels.
- Make use of a backsaw, cut down the waste side of the lines to the chamfer, and then chop out the waste material with a chisel, as you would when cutting dovetails, working from both sides to avoid chip out.
- The bottoms of the sockets must be coved, so they mate with the radius of the knuckles.
- Use gouges that match the sweep of the cope for the end sockets and a straight chisel to shape amongst the knuckles.
- I used a piece of 3/16 in. drill rod for the hinge pin.
- A distance of brazing rod or dowel rod would also work.
- To drill the hole, assemble the joint on a flat surface, and clamp it together end to end with a pipe clamp.
- Then clamp the whole assembly to a fence on the drill-press table, and drill the hole.
- To avoid bit wander, drill a little more than half way through the joint, and then flip the assembly and complete the hole from the opposite edge.
- Drive the hinge pin into the joint, and confirm the action of the hinge.
- It should move smoothly without binding or much squeaking.
- When the joint is open to 90 degree, the two chamfers should form a gapless line.
- Set the aprons on a flat surface to ensure that they sit perfectly flat both when in line and at 90 degree.

How to join the legs and aprons

- It is best to cut the leg-to-apron mortise-and-tenon joints in advance shaping the legs.
- With the legs square, the whole procedure is easier and more accurate.
- The fly legs each have one mortise and the fixed legs have two.
- I cut the mortises with a plunge router, holding the legs in a modest box on which I guide the router.
- You could also chop them by hand or with a hollow-chisel mortiser.
- I find it quick and efficient to cut the tenons with a dado head on the table saw.
- For these tenons, which are $\frac{3}{4}$ in. long, I stacked the dado set $\frac{3}{4}$ in. wide and made the whole cut in one pass.
- The end aprons have a tenon cut on one end and a half-blind dovetail on the other.
- Start the dovetailing by laying out and cutting the tails on the pine inner apron.
- Then use the tails to lay out the pins on the end apron.
- In advance putting the end aprons aside, cut the ogee detail on their bottom edge.

How to make a Cabriole curved emerge

- Cabriole legs do give furniture a certain vitality or spring.
- And they're not all that hard to make.
- A small portion of the work is done on the lathe-the foot and the pad beneath it.
- The rest of the shaping is done with the band saw and hand tools.
- The leg blanks have been milled square and mortised by now.
- Leave the horn at the top, the extra inch that decreases the risk of a split while mortising to provide waste for chucking on the lathe.
- Make a full-sized template of the leg out of thin plywood or poster board, and use it to lay out the cabriole curves on the two adjacent inside surfaces of the leg.
- Then cut out the legs on the band saw.
- Cut the curves only; don't cut out the post block until you've turned the feet.
- If you were to cut away the post-block waste now' it would be hard to center the leg blank on the lathe.
- When you've cut one curve, tape the cut off back into place, and cut the second face.
- Untape the cutoff, and mount the leg amongst centers on the lathe.
- Then turn the major diameter of the foot.
- Measure up from the bottom $\frac{1}{4}$ in. and use a parting tool to establish the pad of the foot.
- With the major and minor diameters defined, use a small gouge or a scraper to shape the foot's profile.
- Lastly, In advance removing the leg from the lathe, sand the foot.
- Then you can take the legs to the band saw and cut away the waste above the knee.
- The remaining of the leg shaping is done at the bench with an assortment of hand tools.
- You can hold the leg with a bar clamp clamped in your bench vise.
- The first step is to fair the band sawn curves with a spoke shave.
- Be particularly cautious working at the top of the foot as this is end grain and will chip simply.
- The joint arris of the leg, though it moves in and out, should be a straight line when seen from the front.

- Once the spokes have work is complete, make use of a cabinetmaker's rasp to cut chamfers on the curves of the leg.
- Leave the curves sharp in the area above the knee.
- After make use of the rasp to round over the chamfers and blend the curves of the leg.
- The cross-section of the leg should be circular at the ankle and square with rounded curves just below the knee.
- When you've completed the coarse shaping with the rasp, refine the curves with a file.
- Further smoothing can be done with a hand scraper and sandpaper.
- Afterward shape the knee to provide a transition amongst the leg and apron.
- Lay out a curved line from the top of the knee to the point where the apron joins the leg.
- Then cut away the waste above the line with a sharp bench chisel.
- With the same chisel, shape the knee in a smooth curve.
- Once the shaping of the legs and knees is complete, saw the horns from the legs.
- Give all the parts a final sanding, and you are ready to glue up the table base.

How to assemble

- With 10 separate pieces comprising its apron, this table presents an unusual challenge in the gluing up.
- The way I do it, there are three stages.
- First glue up the half-blind dovetail joints that link the end aprons to the inner aprons.
- Ensure that the aprons meet at exactly 90 degree in advance setting them aside to dry.
- Afterward glue one fixed and one swing leg to each of the hinged aprons.
- A bar clamp with pads on the jaws will work well.
- To keep the hinge from pivoting, make use of hand screw clamps with light pressure to clamp the hinge to the bar clamp.
- Set all four subassemblies aside to dry overnight.
- To complete the base assembly, you'll need two filler aprons made from secondary wood.
- They are face-glued amongst the fixed section of the hinged apron and the inner apron.
- The fit has to be perfect, so dry assemble the subassemblies, measure the gap and mill the filler apron at that point.
- Glue the filler apron amongst the inner and outer aprons, keeping all three aligned with brads or biscuit joints.
- The final glue up is best done with the base upside down on a flat table.
- While the pieces are dry-clamped, confirm that the hinge will open through its range unimpeded.
- Then glue up the last two “apron to leg” joints.
- After the glue-up, pin all the mortise and tenon joints with ¼ in. dia. pegs.

Rule joints

- I cut the rule joints that connect the leaves and the fixed top In advance roughing out the circular shape of the top.
- I do mill the boards carefully, and scrape or plane off the mill marks In advance cutting the rule joint.
- I find it easiest to cut the joint on a router table.
- First cut the round over on the fixed top with a ½ in. round over bit.
- Guide the top in contradiction of a fence, and make trial cuts on scrap wood.
- Leave a 1/8 in. fillet at the top of the cut.
- Then chuck up a ½ in. core box bit, and cut the leaves to fit the fixed top.
- When installing the rule-joint hinges, leave some leeway for the top to expand and contract with variations in humidity.
- Instead of aiming for a joint that will close exclusively on top, offset the hinge barrels 1/64 in. to 1/32 in. toward the leaf.
- Once the hinges are in, lay out the top's diameter on its underside.
- It can be cut out by hand or with a band saw or a saber saw.
- Scrape and sand the edge to eliminate the saw marks, and shape the edge to a slight belly with planes, files and sandpaper.
- Give the top a final sanding, and attach the base to it with screws driven through slotted holes in screw blocks attached to the inner aprons.
- I completed the table with numerous coats of a tung oil / Danish oil mix.
- A coat of paste wax was applied after the oil finish was completely dry.
- Ensure that the underside of the top and the inside surfaces of the aprons receive the same amount of finish as the visible surfaces.
- If you skimp on finish underneath, the table will take on and lose moisture unequally and could be prone to warping.

Chapter 7 How to make a Gate-Leg Table

A gate-leg dining table I built had eight cabriole legs, and it looked like an insect with a table top on it. I carefully convinced my potential clients to let me design a table with a little more grace that still had the drop leaves and gates they wished for.

The table top was to be an oval large enough to seat eight comfortably. My concern was to lighten the base visually and still provide adequate support for the leaves.

The table that resulted satisfied my clients needs for utility and complemented its surroundings well. Gate-leg tables were intended to save space. A leg-and-apron assembly, or gate, hinged to the table or pivoting on pins set into the table's framework, swings out to support a leaf that's hinged to the table top.

In this way, a small table can be transformed simply into a bigger one. A single gate can support a leaf on a smaller table' or double gates can be used for bigger leaves, such as on this dining table.

The gates can also be on one or both sides of the table, depending on the function of the table and how much extra space is desired. When not in use, two leaves take up hardly more space than one.

For the finest appearance, rule joints are used amongst the leaves and top. This joint looks clean and provides support for the leaves. Double gates can pivot either toward or away from each other.

I decided to have the gates pivot away from each other so that with the leaves down, the gate legs would sit side by side. Measured together, the pair of gate legs are 2 ½ in. wide, or the same width as one of the outer table legs. This lightens the table visually by making it look like there's only one leg in the center of the table rather than two.

Joinery

- The table I built was made of cherry and I used 12/4 stock for the legs to avoid laminating thinner stock to get the 2½ in. I wanted.
- Crosscutting something this thick can be a problem.
- A 2½ in. leg is too thick for a 10 in. table saw blade when the leg is riding in a crosscut carriage with a ¾ in. base.
- I got around this by make use of two miter gauges with a fence screwed on amongst them.
- With this two miter setup, I can cut all the way through the legs in one pass.
- The two gauges also minimize any side-to-side slop that might occur with just one gauge, and the long wooden fence amongst the two gauges lets me clamp a stop to it to index the distance of my cuts for accurate multiple cuts.
- I used mortise and tenon building for all the joinery, routing the mortises and cutting the tenons on my table saw.
- The jigs I used for these two operations are as modest as could be, but they do their jobs well and take practically no time to make.
- The leaves required to fold down without binding on the top of the gate.
- For this to work out, the gates had to pivot out of the way into the table base itself.
- After cutting, routing and dry-fitting all the joinery, I cut notches in the top and bottom rails where the gate legs will nest, dadoing them just ¾ in. deep.
- Keeping the dados this shallow ensured I didn't weaken the rails.
- It also meant I'd have to notch the legs later, so they'd tuck into the rails inside the plane of the table's outer legs.
- I made the notches in the rail a little wider than the combined width of the two gate legs to allow for the swing of the legs as they open and close.
- I debated amongst make use of wooden dowels or steel pins for hinging the gates and ended up opting for the steel pins, which I set in bronze bushings.
- This choice allowed me to deal with glue-ups with something approaching leisure, letting me add on the two gate assemblies

later.

- Another advantage of make use of steel pins and bronze bushings is that they will perhaps last through more than a few dinner parties.
- I drilled the rails for the gate-pivot pins and bushings on my drill press.
- For the $\frac{1}{2}$ in. OD, $\frac{3}{4}$ in. ID bushings I found at my hardware store, I used a $\frac{1}{2}$ in. brad-point bit and drilled exactly $\frac{1}{2}$ in. into the rails.
- After, I centered a $\frac{13}{32}$ in. bit on the dimple at the bottoms of the bushing holes in the rails and drilled all the way through the rails into scrap to prevent tearout.
- Then I took a smear of epoxy and glued the bushings into their holes in the rails.
- The bushings were twice as long as I required, so I came up with a modest, quick way of turning one into two.
- I marked the bushings with a pencil midway along their distance, stuck a $\frac{3}{8}$ in. dowel most of the way through the bushing and then chucked the dowel into the drill press.
- I set my hacksaw on a wooden block and adjusted the drill press table so that the hacksaw blade was even with the pencil mark and the blade's teeth face into the rotating bushing.
- I cut the bushing with the drill press set at its lowest speed.
- I could tell when I was through the bushing Since the blade started spitting sawdust.
- I deburred the inner edges of the bushings In advance epoxying them into the legs and pivot posts.
- As a last step before gluing, I dry clamped each half of the case together to ensure that all fit well.
- And then I larked and mitered the ends of the upper rail tenons on both the ends and sides.

Glue-up sequence

- I glued the vertical columns to the long rails first, taking care to ensure that the frame went together perfectly square by temporarily dry-clamping the legs to the rails.
- Afterward I glued the long side rails to the legs.
- After that joint set up, I joined the two long assemblies with the short end rails.
- It helps not to be too liberal with the glue for the long side rails. Since you will have the glue puddling up inside the mortise for the end rails.
- Then you'll have to wipe or chip the mess out.
- I confirmed both gates as I was gluing them up to ensure they stayed flat, and I was cautious not to over clamp.
- A twisted gate will cause major problems when you try to fit it to the table.
- I sighted across the posts and rails of the gate to see that they were in line.
- If they had been out of alignment, I would have used some judicious clamp-tweaking to pull them flat.
- After the gate assemblies had dried, I notched the gate leg posts on the table saw so that they would mate with the notches on the rails and be out of the way of the leaves.

How to fit the gates together

- I set the two gate assemblies in place so that the center of the pivot posts lined up with the centers of the bushed holes in the rails.
- I trimmed the pivot posts as necessary to fit amongst the top and bottom rails without binding and without too much play.
- I also confirmed to ensure that the reveal amongst the gate legs was even top to bottom.
- Once I was satisfied with how the gates looked in relation to the rest of the table, I marked centers on the pivot posts by dropping a 3/8 in. bit down through the bushing in the top rail and pushing it up through the bushing in the bottom rail.
- Then I just repeated the procedure I went through for the rails on the pivot posts, drilling for the bushing first and then for the steel pin.
- I plugged the hole in the bottom of the bottom rail later to keep the pin from dropping out with the gate attached to the base.
- I also to somewhat beveled the insides of the outer gate legs where they come together, so they wouldn't bind when both were opened together.
- Then I marked and trimmed the bottoms of the legs so that with plastic glides on them, they're just touching the floor.
- If the legs are too short, they won't support the leaves.
- If they're too long, they'll lift the table and stress the hinges connecting the leaves to the table.
- Each gate leg also needs to be tall enough to support its leaf without any sag.
- Leaves that are perfectly flush with the center portion of the tabletop are what you're looking for.
- The issue is that if your leg is at just the right height, there's virtually no clearance to swing the gate by the leaf without scraping the bottom of the leaf.
- To prevent this scarring, I cut the leg amongst 1/16 in. and 1/8 in. less than I really wanted it to be, and later I screwed a wedge in place on the underside of the table to make up for that shortfall.
- This provides the necessary clearance and gives a nice flat appearance across the whole top.

How to make the oval tabletop

- The table top is an oval measuring 60 in. by 82 in.
- I laid out a quarter of an oval on some thick paper folded in quarters.
- I cut out the quarter-oval, unfolded the paper and retraced the whole oval onto a sheet of cardboard to get some idea of how the table top would look.
- I used this rough pattern to lay up boards for the table top.
- If a board had a knot or defect at one end, I used it where that end would be cut off while the final shaping.
- I glued up my top and leaves, sanded them, cut and fashioned the rule joints and hinged the leaves to the center of the top, all In advance I cut my oval.
- I roughed out the oval with a saber saw, e good blade and a steady hand.
- For the finish-cut, I created a router jig.
- I took my time to minimize tearout, especially at the two sections where I was cutting in contradiction of the grain.
- The final pass, which uses the entire cutting edge of the router bit, needs to be done very slowly and carefully.
- Once it's cut, though, you have a perfect oval that needs just a bit of sanding along its edge.
- One other feature I added to the top is a pair of battens beneath each leaf to keep the leaves flat.
- I situated them right behind the wedges, so they also prevent the gates from rotating too far.
- The center part of the table top extends far enough out to the sides that the top rail doesn't get in the way of the battens or prevent them from hanging straight down.

Chapter 8 How to make a Sofa Table Complement

Once I have been asked to design a sofa table. I knew that the piece would have to go with the other furniture in their living room and fit simply into their environment.

The room in question was decorated with an eclectic mix of normal 18th century American and English antiques. The imposing look of the room had colourful floral fabrics and oriental rugs, as well as by a contemporary coffee table.

Even the house itself was extensive architecturally. Since of these things, I decided that the sofa table should incorporate different design motifs and joinery that would match with the restrained stylishness of the home and its furnishings.

Requirements:

- Aside from lovely wood and a rich finish, I felt the real snap of my clients sofa table should come from particulars, like delicate moldings and lively frets.
- The design I come up with blends well with most any room featuring English or American period furniture.
- In the corner of my shop was a particularly lovely piece of highly figured mahogany with wild dark grain streaks.
- It was ideal for the table's lower shelf.
- To make the shelf more visible and also to benefit maintain a feeling of lightness about the table, I chose to inset the tabletop with three pieces of glass.
- This meant I required to finish the aprons and corner frets inside and out.
- For the aprons, moldings, legs and top-frame parts, I selected pieces of straight grain mahogany.
- I cut all the pieces to rough width and distance, leaving extra distance for end tenons.
- After I squared all edges to their faces, I thickened the pieces.
- I cut the leg mortises and apron tenons and drilled and countersunk holes in the aprons for screwing on the top and shelf.

Getting the logs completed

- To create the profile on the outside corner of the leg faces, I first fashioned the corner bead.
- I adapted a cutter by grinding down a standard $\frac{1}{4}$ in. beading cutter until each shoulder came to a point.
- Beading the legs required only one depth and one fence setting, but I had to make four passes for each leg two passes for the center bead and one pass each for the two other corner beads.
- While I used my shaper to do this, a router table would also work.
- I used similar multistep cutting to form each face's swell.
- Made use of two passes, I shaper-cut two curved flutes to form a gentle crest in the middle of each face.
- Again, single depth and fence settings did the trick.
- A couple of passes with a block plane, followed by hand-sanding, rounded off the center crest of the swell.
- Lastly, I cut off the leg blanks tops and bottoms.
- To lighten the legs visually, I chamfered the inside corner of each from the floor up to a point to somewhat below the frets.
- To cut the chamfer and its graceful lamb's-tongue like arc, I pressed my jointer into unusual service.
- I carefully marked and taped to prevent tearout each leg where the chamfer ends in the upper leg.
- Then I clamped a stop block to my jointer's outfeed table the same distance from the cutter head.
- Lastly, I set the jointer's fence to 45 degree and the infeed table to the chamfer depth.
- Since depth of cut is critical, it's a good idea to make a few trial passes on a scrap of $1 \frac{7}{8}$ in. sq. stock In advance you risk your good wood.
- For safety, ensure that the test piece is at least 16 in. long.
- Once your jointer is adjusted properly, slowly feed each leg until the end butts the stop.
- Back the piece off an inch or two from the stop, and lift the leg from the jointer.

How to prepare the shelf

- After cutting out the shelf to dimension, I routed the half-round on the shelf edges.
- Next I made a 1/8 in. thick plywood template to lay out where the legs would meet the shelf curves.
- I sawed along the shelf's marked off curves and edges, while confirming to see that each cut out fit in contradiction of the chamfer of the correcting leg.
- I fit the under-shelf aprons and corner blocks afterward.
- Each end of the apron meets at a 45 degree angle to fit the leg chamfer and is mitered to fit the adjoining apron.
- I secured the aprons and corner blocks to the underside of the shelf and drilled holes in the corner blocks to accept screws that fasten each leg.

How to frame the table top

- The table's three pieces of $\frac{1}{4}$ in. thick plate glass are inset within a top framework rabbeted and doweled together.
- The frame's rail-to-crosspiece joinery is the same for the ends and the intermediate crosspieces.
- I marked and bored dowel holes in the ends of all four crosspieces and in the inner edges of the rails where the crosspieces join.
- By doing this now instead of waiting until the glass rabbets have been cut, you avoid the nightmare of trying to drill into a profiled edge.
- After I dry-assembled the parts with the dowels to confirm their fit, I shaper-cut the $\frac{1}{4}$ in.-deep, full-distance rabbets for the glass.
- I also cut the mating rabbets in the ends of the crosspieces.
- Again, I dry-assembled the entire frame, so I could confirm the joints In advance gluing up.
- After I eliminated the clamps, I fashioned the frame's outside bead, the same size as the one in the legs, and the curved edge leading to the bead.
- The coved molding, which goes under the bead, should not look applied, but instead, should appear integral to the table top.
- To achieve this effect, I extended the molding underneath the top, which also let me simply glue and screw the molding to the underside of the frame.
- When sizing the glass for the inset in the frame, don't go by the opening sizes.
- The distance and width of the glass will essentially be $\frac{1}{2}$ in. bigger to allow the glass to rest on the rabbeted edges.
- Since the glass is not retained by applied moldings, the inset fit is critical for appearance.
- To get a precise fit, I cut out paper templates for the three glass pieces.
- Instead of ordering the plate sizes from a glass shop, I sent the templates to a glass factory, which furnished me glass with 90 degree polished edges.
- In advance I inset the sections of glass, I darkened all the edges with a walnut-colored design marker.

- Darkening the edges makes the inset look neater.

How to mark and carv the frets

- The 5/8 in. thick frets, which visually brace the leg-to-table top curves, are made of solid mahogany.
- In advance I cut out the frets, I made a template from 1/8 in. birch plywood.
- The template extends past the actual fret pattern; once the shape is cut from mahogany, the extra wood at the edges reinforces the unsupported fret spokes.
- These edge stiffeners strengthened each fret while I was sawing and carving its shape.
- I traced the template onto eight pieces of mahogany that had the grain running at a 45 degree angle to the edges.
- I then cut the frets' curves square.
- If the leg-to-apron angle is not exactly 90 degree, fitting the frets will be hard.
- I band sawed the frets' outer curve, and with scroll and coping saws, I cut away the interiors, leaving the edge reinforcement intact.
- Since the frets must be carved in pairs with their grain opposing, I marked the front face of each.
- Afterward I drew ridge and depth carving guidelines on all the front faces.
- Much like the roof of a house, the ridge line describes where the two sloping faces of a fret spoke meet; the depth lines indicate the bottom of each slope.
- While carving the frets, be mindful of short-grain and the inherent delicacy of the fret spokes.
- I've found that gently paring away thin slices of wood with a razor sharp chisel is best.
- Once I carved all the frets, I sanded them smooth.
- Then, to eliminate the edge stiffeners squarely, I used my table saw as follows:
- First, I set my gauge to 90 degree and situated its fence close to the blade.
- This is because the fence supports the work right up near the cut, I didn't have to make use of a hold-down, which might fracture the

delicate spokes.

- Then, holding the piece right to the fence with my hands well clear of the blade, I cut an edge stiffener off each fret.
- It's best to make the cut in a few passes, as you gradually approach the pattern lines.
- Lastly I rotated the fret 90 degree and repeated the procedure to eliminate the other stiffener.

How to assemble

- I drilled $\frac{1}{4}$ in. holes to receive dowels that attach the shelf curves to the inner chambers of the legs.
- In advance assembling the table, I sanded any parts that weren't already sanded and stained the table a mahogany colour.
- When the stain was dry, I assembled the major components, and then I completed the table with lacquer and a topcoat of padding lacquer, which I rubbed out by hand.
- To attach the frets, I drilled one edge of each fret where it would be doweled to the leg and drilled a correcting hole in each leg I situated each fret by aligning its dowel to the leg and carefully drilled up through the fret into the underside of the apron.
- With the fret and its leg dowel glued in place, I inserted another dowel into the apron hole.
- I trimmed the end of this dowel flush to the fret.
- While the dowels won't be visible once the table is in place, I stained and lacquered all the dowel ends, so they'd match the frets in advance I waxed the entire table.

Chapter 9 How to make Convertible Tables

Some pieces of furniture literally work. The tambour of a roll top desk, or even a rocking chair, allows-or perhaps even demands-human interaction. Similarly, but in a more subtle manner, the game table, and the spinet desk are hard to work with.

Both perform double duty and do so gracefully, but unlike a rocker or a roll top, they hide their alter egos. Perhaps the element of surprise is partially responsible for my satisfaction in owning them; when visitors comment on my hall tables, they're fascinated and drawn in by the transformations that occur.

Designing and building these tables was satisfying as well. In describing them, I will provide you with the critical concepts and relationships that make these pieces of furniture work, so you can build similar pieces that suit your particular needs.

I was upset for years by a card table that swayed like a tall pine in a gale, I had frequently anticipated building a sturdier model. In addition, I was fed up with having to burrow through an overstuffed coat closet to drag out my old folding table.

I wanted a table that provided more playing surface than standard models but didn't dominate my living room. A 19th-century Dutch game table caught my eye.

Its rails folded on two sides, allowing it to transform from a full-size card table into an eye-catching side or occasional table that's only half as large.

Even though the Dutch table was more than 100 years old and the hardware was fairly worn and loose, it was still remarkably sturdy.

I decided to try my hand at building a similar table. Rather than make use of reproduction hardware, I substituted contemporary, precision hardware and I adjusted tire size to fit my needs.

Since that first effort, I've built two more of these tables. The actual building was rather straightforward, but the design required a bit of thought.

How to divide the folding rails

- The most critical aspect of the design was determining the distances of the various pieces of the folding rails.
- I found it easiest to work backward from the desired final dimensions of the table top.
- On the basis of comparison with existing card tables, I decided to build my table 34 in. sq. when open and half that width closed.
- A 2 ¼ in. overhang all around gave me a base that's 29 ½ in. sq when open and folds to 12 ½ in. when closed.
- I arrived at these numbers logically; the table's proportions when closed pleased my eye, and I knew it would provide plenty of space when open for cards, tea and such.
- Having established these dimensions, I simply subtracted 9 in., the distance amongst legs when the table is closed, from 26 in. the distance of the front and back rails amongst the legs.
- This gave me 17 in. as the correct overall distance for the exposed portions of the two lasting pieces of each folding rail when the table is open.
- Nevertheless, this is only the exposed overall dimension.
- A half-lap notch cut into the back rail piece and the correcting notch cut into the middle rail piece hide the folded rails when the table is closed up and help stiffen the back-to-middle rail-piece joint when open,
- For the table to close properly, these notches must be long enough to accommodate the thickness of the two folding rail pieces and the front back flap hinge when folded.
- For my table, I cut the notches 2 ¼ in. long, which gave me a little play.
- Adding this 2 ¼ in. to the 17 in. gave me a total of 19 ¼ in. for the middle and front rail pieces on each side.
- At this point, common sense might tell you simply to halve that number to give you the appropriate distance for each of the enduring pieces of rail.
- I've found, though, that cutting the front rail 1/8 in. longer than the middle piece prevents the folding rails from binding in the corner.
- This is because the back flap hinge isn't mortised into the front leg and spacer block, so the end of the front rail piece must extend past the center point of the hinge pin, if the rail is to butt up snugly

in contradiction of the leg.

- Therefore, the front rail piece must be $\frac{1}{8}$ in. longer, if it and the middle rail piece are to fold parallel to the front rail and not bind.

How to install the hinges

- Once I'd worked out these relationships, I felt comfortable beginning building.
- I cut the leg blanks to $1\frac{3}{4}$ in. sq. by about 28 in. long, which left me an inch for trimming the legs to final distance and removing chuck marks from the top ends after I'd turned them.
- I turned the legs and trimmed them to distance.
- Then I cut the $\frac{1}{2}$ in. sliding-dovetail mortises for the fixed front and back rails and for the fixed back end of the folding rails on my router table make use of wooden stop blocks and running a test cut on a piece of scrap first.
- When milling the rail stock, I left it to some extent wide so that I could trim away any tearout along the edge that might outcome from routing the sliding dovetails, I then selected and routed the face side of all my sliding dovetails.
- I rearrange the fence for the other half of each dovetail, confirmed the cut on a piece of scrap and made some minor adjustments to get a good, snug fit in the dovetail mortises in the legs.
- Once satisfied with my cut, I routed the back side of the dovetails on all rails.
- In advance cutting the two folding rails into three pieces each, I routed dadoes near their bottom inside edges to accommodate the $\frac{1}{4}$ in. plywood spreader that slides forward and locks the rails open.
- I then cut each folding rail into three pieces, as described above, and marked them so that the grain on the rails of the assembled piece would be nearly continuous.
- Appropriate hinge installation is as essential as is determining the requisite distances of the folding rail pieces.
- I routed mortises for the offset-knife hinges that join the front and middle section on my router table, and then I cut the half lap notches on the back and middle rail pieces.
- After installing the offset-knife hinges into the mortises, I mounted the back flap hinges on the overlapping back and middle rail pieces.
- It is essential that this hinge is mounted with its pin perpendicular

to the top edge of the rail, so the rail won't bind and so the table top will sit flat.

- Afterward, I glued and clamped the leg-to-rail dovetails.
- After they dried, I inserted the ¼ in. plywood spreader into the dado near the bottom of the rails and screwed the front pieces of rail to the front legs and to a spacer block.
- Again, it's very important that the hinge pins be perpendicular to the rails.
- After assembling the base, I cut and installed diagonal corner braces to keep the curves rigid.
- Since I've found it easier to work with narrow boards when drilling deep mortises like those required for the three “soss” hinges I used to connect the two leaves of this table top, I ripped the innermost board of each leaf to about 3 in wide and routed the mortises for the hinges In advance gluing up the leaves.
- Two hinges might have been adequate, but the third hinge should benefit prevent the leaves from warping.
- Once the hinges were installed, I glued up both leaves and finish-sanded them.
- The table top is attached to the base with a screw through each of the diagonal corner braces.
- The screw holes should be elongated to allow for cross-grain movement.

Snippet desk

The first true spinet desks were made for school use of in the 1830s by fitting cast-iron cabriole legs to melodeon cabinets boxes which comprised the innards of an organ-like instrument.

The desk I used as a model was made at a later date, though, and is a modest box with a front panel hinged to a folding top. Turned wooden legs are attached to the box's bottom with hanger bolts, and the interior of the box comprises a slide-out writing surface and pigeonholes for paper storage.

Time has taken its toll on this piece, leaving it a bit wobbly, but the desk's ability to transform from useful writing desk to demure hall table fascinated me.

I wanted to build a similar piece that retained the style and character of the original, but was more stable. I accomplished this by make use of sliding dovetails for all leg-to-rail joints except for the front fascia piece, which I tenoned into mortises in the front legs.

I also wanted a bigger writing surface that would be more suitable for adults, so I increased all dimensions of the piece proportionally. The resulting piece is a modest, yet elegant desk, and the writing surface can be hidden in a moment by pushing it in and then folding the top down.

How to assemble the desk

- I first glued and clamped the back rail and legs and the front fascia and legs together.
- I let them dry, and then glued the front and back assemblies together with the side rails.
- Afterward, I screwed the cleats that support the writing surface all around the inside of the box.
- The cleats are flush with the top surface of the front fascia and the side cleats are notched to fit around the legs.
- To fill the gap amongst the side rails and the inner surface of the legs, I glued and screwed L-fashioned guide pieces, one piece of wood routed out to the side rails.
- The guide's vertical arm comes just flush with the inside edge of the legs, and the horizontal arm extends beyond the legs to form a pocket amongst itself and the side cleats so that the writing surface can slide freely.
- These guides also support the removable pigeonhole assembly.
- I constructed the assembly from 3/8 in. stock and intended it to accommodate standard writing paper and envelopes as well as to provide miscellaneous storage.
- With the pigeonhole assembly in place on the writing surface guides, I measured for filler blocks on either side and for the top cleats, through which I screwed the back leaf of the folding top.
- The filler blocks and top cleats were screwed to the side rails through elongated holes to allow for wood movement.
- I'd glued up the writing surface ahead of time so that it would be ready to trim to size when it came time to assemble the desk.
- I used a glue joint tongue-and-groove bit to rout the ends of the boards and the end caps, but I only glued the end caps to the main field of the writing surface in the middle to allow for expansion and contraction.
- Now, with the box assembled and the guide pieces installed, I trimmed the writing surface to fit neatly amongst the front legs and to set back far enough to allow the false drawer front to close flush with the fascia.
- Two short dowels glued into the bottom of the writing surface act

as stops, and a brass sliding-door pull is mortised into the top.

- To fill the space amongst the pigeonhole assembly and the writing surface, I glued and screwed a narrow filler piece to the writing surface so that it would protrude about an inch beyond the pigeonholes when fully open.
- The top consists of two equal-width leaves joined with “soss” hinges, like the top of the game table.
- To mount the top, I ran screws up through the top cleats at either side of the box and into the back leaf.
- Then, with the top closed, I marked the underside of the front leaf for the false drawer front, cut the front panel to fit and attached it to the front leaf with a piano hinge.

Chapter 10 How to make a Coffee Table with a Glass-top

When a client asked me to design a glass-top dining table, I decided to build a coffee table as a prototype to work out the joinery and design particulars. The resulting table turned out well and required less than 7 bd. ft. of 1 in. thick scrap lumber.

The table's building is rather modest. The four leg-and-apron units are assembled with miter joints strengthened with floating tenons. These units come together with glued miter joints that run the length of each leg.

The glass top sits in rabbets in the top inside edges of the aprons and is further supported by glue laminated diagonal rails joined with half-laps and screwed into the inside curves of the aprons. I used miter joints throughout the table's design resulted in an unexpected benefit: I didn't have to contend with finishing any end grain.

How to miter and join the legs and aprons

- I cut and assembled the four leg-and-apron units in advance tapering the legs and shaping the underside of the aprons to ensure a smooth transition.
- To make the leg-and-apron units, I first cut the eight legs and four aprons to the dimensions in the drawing.
- I then mitered each leg on one end and each apron on both ends. Whether you cut miters on the table saw by setting the miter gauge to 45 degree, as I do, or on a radial-arm saw or a chop saw, always test the setup by mitering two scraps and confirming the joint with a square.
- Since end miters, like those on the legs and aprons, are structurally weak joints, I strengthened them with ¼ in. thick floating tenons, which also increases the gluing surface.
- I laid out the mortises for the tenons so that they would be ½ in. from both the top of the aprons and the outside edge of the legs to keep the tenon from interfering with the rabbet for the glass.
- I used a slot mortiser to cut the mortises, but you could also bore them on a drill press or with a doweling feature and portable electric drill.

- The mortises could also be cut with a table-mounted router and fence or a hand-held router and template.
- Whichever technique you use, be sure the mortises are centered so that the surfaces of the legs and aprons will be flush when assembled.
- Making passes with each side of the leg or apron in contradiction of the fence or table will automatically center the mortise but may also leave it a bit wider than $\frac{1}{4}$ in.
- Nevertheless; this is not an issue as the tenons will be cut to fit into the mortises, and tenons should be $\frac{1}{32}$ in. shorter than the combined depths of the mortises.
- A few test cuts will yield a perfect fit.
- Dry-assembling each leg-and-apron unit ensures that the miters are tight, that the tenons don't bottom out in the mortises and that the legs are square to the aprons.
- I did most of my gluing on my saw's outfeed table since its plastic-laminate surface is easy to clean.
- After applying glue to the miter faces and inside the mortises, I reassembled the first leg-and-apron unit, holding it together with three bar clamps.
- I laid the first clamp flat and parallel to the apron, to squeeze the top of the legs to the apron miters, and tightened it to somewhat until the joints began to slip.
- Then I situated the two enduring clamps upright from the bottoms of the legs to the top of the apron and began tightening them.
- The trick was to tighten all three clamps alternately so the miters pulled together perfectly without slipping.

How to taper and shape the legs and aprons

- Afterward, I laid out the curves and profiles of the tapered legs and underside of the apron.
- I drew the curve amongst the legs and apron used a coffee can.
- I band sawed to the waste side of the line and then completed to the line with a belt sander, a pneumatic sander and by hand-sanding.
- After all four leg-and-apron units were band sawn and sanded, I mitered the outer edge of each of the eight legs.
- My first inclination for cutting these long miters was to use the table saw with the blade tilted to 45 degree.
- Nevertheless, this didn't work well as the rip fence was too far away from the cut, resulting in chatter and vibration at the unsupported bottom end of the legs.
- I found that I could get nearly perfect miters by tilting my jointer's fence to 45 degree and making a series of passes until the last pass just met the face of the leg.
- After both legs of all four units were mitered this way, I used the table saw to rip the rabbet for the glass top in each apron.
- Since this rabbet will be visible through the glass, it had to be sanded carefully.
- In advance gluing up the leg-and-apron units, I also sanded all inside surfaces, starting with 120 grit paper and working up to 320 grit.

How to join the legs and aprons

- Gluing the leg-and-apron units together is not an ideal job.
- It's not hard, but it must be done rapidly and efficiently, so laying out the clamps and planning ahead are essential.
- Almost any clamping arrangement will work.
- I used a band clamp around the apron and spring clamps and rubber bands along the legs.
- In advance gluing, I dry-assembled the four units, make use of tape and rubber bands, confirmed the miters along the legs and touched them up as required with a hand plane.
- After gluing up the table, I allowed it to dry and then sanded the outside faces to 320 grit.

How to install the support rails

- The curved support rails were made by laminating three strips of cherry over a curved plywood form.
- To simplify the procedure, I first laminated two wide strips and then ripped them to form the four required rails.
- The form for the laminations is simply a stack of five pieces of $\frac{3}{4}$ in. thick plywood glued and screwed together into a block.
- I laid out and band sawed a 36 in. radius convex curve along one edge of the block and then disc-sanded the curve fair and smooth.
- I made the strips for the laminations by first re-sawing two $\frac{7}{8}$ in. thick pieces of cherry, $3\frac{1}{4}$ in. wide by 44 in. long, into six $\frac{3}{16}$ in. thick pieces on the table saw.
- Then I planed each strip to its $\frac{1}{8}$ in. final thickness.
- Since my planer has a minimum capacity of only $\frac{1}{4}$ in. thick, I used a piece of $\frac{3}{4}$ in. thick plywood as a temporary planer bed and screwed a lip to the underside of the plywood to keep the bed from being drawn through the planer.
- To laminate the curved rails, I applied glue to three of the strips with a narrow paint roller, wrapped them in plastic to minimize the mess and held them firmly to the form with a 3 in. heavy-duty band clamp.
- After the first lamination had dried for 24 hours, I repeated the procedure for the second set of rails.
- When the second lamination had dried, I scraped off all the excess glue and jointed one edge.
- Then I ran the jointed edge in contradiction of my table saw fence and ripped the laminations into the four $\frac{1}{2}$ in. wide rails.
- The placement of the miter joints amongst the two pairs of rails is taken from the table, but the table must first be square.
- Measuring the diagonals will reveal problems, and a clamp can draw the table back to square if necessary.
- I placed one rail at a time diagonally across the top of the table, so the outside edge of the rail intersected the inside curves.
- With a square, I transferred these intersecting points along the side of the rail and marked the top edges at each end.
- Then I aligned a straightedge with both marks across the top of the

rail to define the table's diagonal and to bisect the angle amongst the rails.

- I scribed lines across the top of the rails with a knife, band sawed close to the lines and disc-sanded to them.
- With the first rail marked and cut, I clamped it in place inside the table to help align marks for the second rail.
- I repeated these steps to mark and cut the other rails.
- After sanding the rails to 320 grit, I glued pairs of them together, taping across the miters, to form football-fashioned glass supports.
- When the glue was dry, I dry-assembled the glass supports into the table to mark for the half-lap joints where the supports intersect.
- First I slid one support into place diagonally amongst the curves of the table frame until it was about $\frac{1}{2}$ in. below the rabbet.
- Then I situated the second support unit diagonally amongst the opposite curves, directly on top of the first.
- Spring clamps on the table legs disallowed the supports from slipping farther down.
- With a knife, I scribed the bottom of the top support and the top of the bottom support where the curves intersected.
- Then I eliminated the supports and extended these lines halfway up the sides.
- After cutting along the lines with a dovetail saw, I chiseled the bottoms flat.
- Lastly, I slid the two units together and trimmed them with a sharp chisel to get a perfect fit.
- Once the glass supports fit properly, I glued them together and inserted them into the table.
- With spring clamps holding the supports in position, I drilled a hole for a wooden plug and then a pilot hole for a screw in each of the long aprons' curves and into the curved supports mitered curves.
- After inserting the screws and plugging the holes, I gave the entire table a final sanding with 320 grit paper.
- Four hand-rubbed coats of “Watco” oil provided a satisfying satin sheen.
- Experience has taught me that it's better to take the completed table to a reputable glass shop and have a glass top cut to fit than it

is to phone in the dimensions of the glass.

- For a completed look, I had the edges of the ¼ in. thick plate glass ground, and to protect both the glass and the table, I glued round leather pads in each corner of the table and at the intersections of the supports.

Chapter 11 How to make a Trestle Table

Having virtually no furniture, though, I required to make some basic utilitarian pieces including a kitchen table. I went to the local lumberyard and purchased just enough 2x stock.

I wanted to try it in a nicer wood, so I chose clear, vertical-grained red cedar as it's highly rot-resistant: The table can be used outside as well as in the kitchen or dining room.

Building this table can be done just as simply with power tools as with hand tools and may even be to somewhat quicker. But the scale of the joinery and the straightforwardness of the design also make this an ideal venture on which to practice cutting joints by hand.

I make use of hand tools exclusively, partially as acquiring and practicing hand-tool skills is what initially attracted me to woodworking. But mostly I make use of hand tools as I really appreciate planing and cutting joinery by hand, and I really don't appreciate the scream of electric saws, routers and sanders.

How to build the trestles

- I built the two trestles first, then the related pieces; stretcher, wedges and battens and, lastly, the top.
- By having the trestles and related pieces ready when I finish the top, I can attach the battens to the underside of the top right away, connecting top and base in advance there's any chance of major wood movement.
- If I built the top first, it could have warped while I was building the base, making it hard to connect the two.
- I used dimensional red cedar for this venture, which I cut to distance, planed smooth and laid out for mortises and tenons.
- I clamped each of the trestle members in my bench vise and bored holes for the mortises I use of a brace and expansion bit.
- I set the expansion bit to the width of one of my mortise chisels and situated a depth stop to just less than half the depth of the mortise.
- To ensure the holes are perpendicular to the surface of the

workpieces, I clamped the work so that my drilling motion keeps the bit naturally level.

- I sight along the bit and the sides of the workpiece to keep the bit from wandering to the left or right.
- After boring to the depth stop, I repeat from the other side, leaving just a wisp of wood in the middle.
- I cleaned out the mortises with a mallet and a registered mortise chisel, which has square sides but is not as thick as a standard rise chisel.
- I kept the blade perpendicular to the distance of the mortise, and I chopped from one end of the mortise to the other, staying just shy of the marked top and the bottom shoulder lines.
- After hogging out most of the mortise with the bit and brace and the registered mortise chisel, I came back with a paring chisel.
- I pared the mortise clean, squaring the ends and making sure the sidewalls are rather smooth and square.
- Once I have completed all six trestle mortises, I cut the shoulders and then the cheeks on the tenons of the vertical trestle members, smooth all tenon surfaces with a shoulder plane and kerf the tenons diagonally.
- Kerfing the tenons diagonally, toward the outside of the tenon, causes the outer sections of the tenon to splay, almost like a hinge.
- Diagonal kerfs decrease the likelihood of a crack extending beyond the tenon when I drive the wedges home later.
- Cracks are also less likely with diagonal kerfs as the plane of the saw kerf does not follow the grain.
- Afterward, I fashioned the two horizontal trestle members a 45 degree bevel at the ends of the top pieces, which support the tabletop, a 3/8 in. taper on either side and a 5/8 in. taper on the top of the foot piece.
- I also planed dovetail rabbets into both sides of both top trestle members where they'll slide into the battens on the underside of the tabletop.
- I rounded the ends of the foot pieces to somewhat to reinforce that motif in the tabletop.
- Then I relieved the bottom of the foot so that it would rest on its two ends, and I to somewhat chamfered all sharp edges.

- With all trestle pieces completed, I applied glue to all mating surfaces, started the wedges into the tenons, inserted the tenons into the mortises and then clamped the trestles closed.
- I tapped the wedges home.
- The Afterward morning, I sawed them flush and then planed smooth those surfaces on which the tenons were exposed.

Finishing the stretcher and wedges

- I planed the stretcher stock smooth, crosscut it to distance and marked out the tenons.
- Then I crosscut the shoulders, ripped the cheeks and cleaned up the tenon surfaces with a shoulder plane.
- I installed the stretcher tenons into the two trestle mortises, marked the stretcher for the wedge mortises and then disassembled and chopped the mortises.
- Since this mortise is so narrow, I skipped drilling it and just pounded out the mortises with a mallet and a sash mortise chisel.
- Some furniture makers like to work from the middle out when chopping mortises.
- I prefer working from one end to the other, being cautious at the ends not to round over or crush the crisp shoulder of the mortise.
- Also, as this mortise is tapered, I was particularly cautious not to gouge the inclined plane in contradiction of which the wedge will bear.
- The more perfect the wedge and this inclined plane mate, the less prone the wedge will be to slip and the more solid will be the table's structural elements.
- As a final touch on the stretchers, I rounded the ends side to side, make use of a rasp and a file, to go along with the foot and the tabletop.
- I cut the wedges from scrap.
- The taper is slight: $\frac{3}{4}$ in. over a foot.
- It's vital that the taper not be too steep as that would cause the wedges to become unseated with the slightest bump to the table.
- I chamfered the top of both wedges, so they wouldn't split out when tapped into their mortises.
- I did the same to their bottoms for the sake of symmetry.
- I left the sides with crisp edges to maximize the bearing surface in the mortises.

Finishing the table top

- For the top, I edge-jointed, glued and clamped three red cedar 2 x 12s.
- I sprang a batten on each of the two sides to mark subtle fair curves that sweep from the centers of the sides in $\frac{1}{2}$ in. to the ends.
- I also marked fair curves along the ends in $\frac{3}{4}$ in. from the centers to the sides.
- These curves make the table.
- I scrub-planed top and bottom roughly flat, left the bottom, that way and smooth-planed the top.
- I scribed the underside of the table 2 $\frac{3}{4}$ in. in from the edge, and then I marked the edge down 1 in. from the completed top surface for a bevel to lighten the appearance of the tabletop.
- I used a drawknife to eliminate most of the waste, followed up with a scrub plane and lastly took the bevel to the two scribe lines with a smooth plane.
- I chamfered both top and bottom arrises of the table's edge with a block plane.
- I ripped, crosscut and planed the four battens that connect the tabletop to the trestles and drilled and elongated screw holes in the battens.
- I screwed them to the underside of the table make use of the stretcher connected trestles as spacers.

Chapter 12 How to make a modest Coffee Table

Ever since I started building furniture, I've taken pleasure in making the many different components in a piece and seeing them all fit together like pieces of a puzzle.

As I progressed as a craftsman, the joints got better and more complex, and my pleasure of the procedure increased. But making a lot of tight-fining joints can be quite time-consuming and expensive, and most of my clients have tight budgets.

They have come to me as they want something more than they can get in the department store, but they can't necessarily afford to have me spend a lot of time doing greatly detailed work.

I frequently have to find ways to compromise while still aiming to develop beautiful furniture of sound building. I look for ways to simplify, and to make use of what tools and supplies I can afford and to make bounded resources grant handsome returns.

I had a challenge of this kind when a client approached me about making a coffee table. Together we settled on a basic table in the Craftsman vein and a carefully trimmed budget for the job.

Two hallmarks of Craftsman furniture are pinned through-mortises and legs coopered or veneered so quarter sawn grain shows all around. But I decided to leave them out of my table, substituting the straightforwardness of loose tenon joinery and solid-wood building.

How to lay out lumber

- I went looking for about 30 bd. ft. of quarter sawn white oak.
- What I found was a few very rough boards that had turned quite black.
- After the first pass through my planer, I could see that the wood was not white oak.
- What emerged was beautiful red oak of a diversity I had never seen In advance.
- I decided it would suit my purpose well.
- With the freshly planed boards arrayed on my outfeed table, I studied the grain and color to decide where the boards would be used to their best advantage.
- First I selected the boards for the top.
- These should be picked not only for their beauty but also with an eye toward having even color and straight grain along the edges, so they match well when joined together.
- I needed four pieces for the top.
- I first crosscut them a few inches over distance and arranged them as they would be joined.
- After that, I marked a triangle across all four, so I could simply orient them.
- Then I arranged and marked the shelf boards and cut them to rough distance.
- I don't have a jointer, but with short boards, I can get good glue joints by ripping them a few times on the table saw, taking off about 1/16 in. with each pass and confirming them for fit after each cut.
- For longer stock or “waney-edged” pieces, I clamp a straightedge to the board and joint it with a flush-trimming router bit.

How to complete the flat top

- I glued up the top and shelf with pipe clamps, I used a $\frac{3}{4}$ in. dowels laid parallel to the boards as clamping blocks.
- The dowels concentrate the pressure right in the centre of the stock and minimize the clamps tendency to tweak the boards up or down.
- I keep a stock of dowels of various diameters set aside for this purpose.
- I find it much easier to grab a pair of the correct size than to hunt down scrap or make up pressure blocks to the thickness of the work piece each time.
- After the glue had set, I belt sanded the slabs.
- I run my sander diagonally to flatten glued-up panels, feeling for the high spots and concentrating on them to attain a nice, flat surface.
- I start with a 100-grit belt, first sanding diagonally and then with the grain.
- Then I change to a 120-grit belt and sand with the grain only.
- People frequently complain that a belt sander is hard to control and easy to gouge with, but I have advanced a good working relationship with my 3 in. by 21-in. Makita.
- With practice, you can gain the touch required to flatten a wide surface.
- Once the belt sanding is completed, I switch to a random-orbit sander and work through the grits, starting with 120 and moving on to 180 and 220.
- Then I hand-sand with a block and 220-gritpaper to eliminate any slight swirl marks the random orbit may have left.
- On a rather forgiving wood like oak, this step is my last, but with something hard and close-grained like cherry, I might finish up with 320-grit paper.
- Someone once asked me when you know you've sanded enough, and the truth is that never enough.
- There's always more you could do, but it's vital to work technically and take all to the same level of finish.
- Instead of belt sanding, you could make use of hand planes to

flatten the top and shelf or rent time on a big thickness sander.

- Panels this wide cry out for a panel saw of some kind when it comes to crosscutting, but I don't have one.
- Instead, I clamp a crosscutting fixture square to the sides and cut one end with a hand-held trim saw, which is a small circular saw.
- When I had one end straight and square, I made the second cut on the table saw about $\frac{1}{4}$ in. longer than required.
- Then I flipped the top around to make a finish cut on the trim-sawn end.
- I laid out the width so the two outside boards were roughly equal and ripped both sides.
- I used this technique, and I got good table saw cuts on all four sides with no tear out.
- A few strokes with a block plane were all that was required to clean up the edges.

How to build up the legs

- I glued up the blanks for the legs by sandwiching a piece of $\frac{1}{2}$ in. stock amongst two $\frac{3}{4}$ in. pieces.
- I typically make legs from single sticks, but in this case, I couldn't obtain thick enough stock when I required it.
- I took a lot of care with these laminations, matching the layers for color as well as grain orientation.
- When I was done, the joints were barely perceptible even under close examination.
- I ripped the twelve pieces for the leg blanks $\frac{1}{4}$ in. oversized in width and 5 in. oversized in distance.
- The extra width gave me some leeway for slippage while the glue-up and for the final ripping to distance across.
- The extra distance ensured that any snipe left by the planer in final thicknessing could be cut off.
- I arranged the legs carefully, so matching grain would show on each side of the table.
- Then I held them together, and across the top end grain of the four pieces, I drew a single triangle.
- This quick marking technique makes it easy to establish the orientation of a part at any point in the building procedure.

Loose tenoning

- Loose tenoning is the technique I use most frequently for making structural joints as it is robust and straightforward.
- Also called a splined mortise or floating tenon joint, the loose tenon joint is simply a pair of mating mortises with an independent tenon to span them.
- With a mortising fixture the joints are easy to make.
- You could also make the mortises by hand, on a router table or with a hollow-chisel mortising setup.
- I make loose tenons from the same material as the table, so all seasonal movement will be the same.
- Just ensure the grain runs the distance of the loose tenon.
- For this table, with 1-in. wide mortises, I first ripped long strips 15/16 in. wide and 7/16 in. thick.
- Then I thickness-planed them to exact size, confirming them every pass or two in a sample mortise until I got that wonderful feeler-gauge fit.
- If you have to use strength to pull the spline from the mortise, the fit is too tight; if there's no resistance, it's too loose.
- Making the tenons 1/16 in. undersized in width leaves room for excess glue and also gives you some welcome lateral adjustment in the glue-up.
- I rounded over the tenon edges on the router table and then cut them to distance 1/8 in. shorter than the combined depth of the two mortises.
- With all but the shelf and spindle joints cut, I dry-assembled the table.
- At this point, I measured amongst the stretchers to find the distance of the shelf.
- This dimension could be calculated, but as even a slight misplacement of a mortise or variation in the thickness of the stretcher could throw all off, I find it better to measure the distance once all else has been done.
- I cut the shelf to size in the same way that I cut the top.
- It is attached to the stretchers with loose tenons, but only the center tenon is glued.

- The outer tenons, cut narrow by 1/8 in. and left loose, give the shelf room to move with changes in humidity while supporting it firmly.
- The spindles are too small for loose tenons, so I tenoned their ends and cut mating square mortises in the stretchers and aprons.
- As I played around with the placement of the spindles, I decided that a ¼ in set-back from the outside edge of the stretchers and aprons gave it the feeling I wanted.
- It's surprising what a difference 1/8 in. can make in places like this.
- If you pull the spindles up to the edge of the rails, you create a flat surface; if you push them in a bit, suddenly the spindles impart a feeling of structure and strength.
- Given the thickness of the stock I had, this decision meant cutting tenons with no shoulder on the outside face.
- I could have used denser material for the aprons and stretchers, but none was readily obtainable.
- So to get the job done and to keep my expenses down, I worked with what I had.
- I cut the tenons with a dado set on the radial-arm saw.
- I chopped mortises for the spindles on the drill press with a 3/8 in. mortising chisel.
- I wanted the mortises to be 3/4 in. by 3/8 in., so I made a 3/8 in. spacer block, which I placed in front of a stop block on the fence.
- Once the stop block was clamped down at the right spot, I could make a mortise in two quick chops, one with the spacer block and one without.
- The sides of the mortises required a little clean-up with a chisel, but the ends, which are severed end grain and provide no glue surface, I left rough.

Curved supports

- With all the other parts milled and joints cut, I turned to the corbels.
- These curved supports, borrowed from architecture, are one of the elements that differentiate Craftsman furniture.
- In this case, they're not structurally significant, but like the deep set-back of the spindles, they lend the piece a sense of weight and solidity.
- Since I'd left out other decorative particulars, I wanted to get these right.
- I started by making a template and I drew what I felt was a pleasing shape for the corbels on a ½ in. piece of plywood and cut it out with a jigsaw.
- To fair the curve and rid it of saw marks, I used a technique I learned from a friend with boatbuilding involvement.
- I folded sandpaper around 1/16 in. thick sliver of wood.
- The sliver conforms to the curve, riding over low spots and cutting the high spots.
- If the initial cut is reasonably true, this rapidly develops a perfectly fair curve.
- Then I used the piece of plywood as a template to shape the corbels.
- I first jig sawed the corbels a bit too large and then nailed the template to them with a couple of brads placed in the edge that would be let into the leg.
- By running the template in contradiction of a flush-trimming bit in the router table, I rapidly developed identical copies.
- The corbels fit into the leg with a stopped dado, which I cut on the table saw using a stacked dado blade.
- I set the fence to position the dado in the center of the leg and clamped a stop block to the fence so that the cut would stop exactly where the corbels end.
- When the leg hit the stop block, I turned the saw off, waited for the blade to stop and eliminated the leg.
- It is quite easy to finish the stopped dado with a chisel.

Completing Assembly

- The corbels were the last parts I made.
- When they were completed, my favourite moment had arrived-the time for dry-assembly.
- If all the joints are just right, dry-assembly is a joy to do as all snaps together and holds firmly without clamps.
- In this case, I could lift the whole assembly by one leg without anything coming apart.
- This little act gave me a thrill and impressed my customer.
- In advance final assembly, I block sanded all and eased all the edges.
- Some sanding will always be required after glue-up, but it is easier to do the bulk of it beforehand when all the pieces lie flat and all their faces are easy to reach.
- I did the assembly in stages, first gluing up each end and later linking them together.
- I started the glue-up by fitting one set of spindles into their stretcher and apron mortises.
- As soon as these joints were pulled tight, I glued the apron and stretcher to the legs.
- It's vital to square this subassembly by measuring the diagonals with a tape.
- And I made sure the legs ended up in the same plane by sighting across them.
- By gluing all this in one operation, I disallowed the possibility of having a skewed spindle assembly that would not fit neatly into the legs.
- When the glue dried, I glued the two side aprons and the shelf amongst the end frames.
- I did this on a flat surface, confirming the diagonals again to ensure that the table ended up square and making certain all four legs were solidly on the surface.
- Frequently a clamp or two must be skewed a bit to achieve this and to ensure the table will not rock later on.
- I attached the top with cleats screwed solidly to the apron.
- To accommodate seasonal movement of the top, I drilled

oversized holes up through the cleats and pulled the top tight with pan-head screws fitted with washers.

Final touches

- For the finish, I applied three coats of Antique Minwax.
- I rubbed in the final coat with fine steel wool and immediately wiped it off, leaving a beautifully smooth finish that, with occasional re-oiling will only get more beautiful with time.
- This table was my first effort in the Craftsman style.
- I had initially suggested this style to my client as I felt that it would fit the decor as it stands up so well to heavy use.

Bonus Chapter How to fit a Chair to a client

- The first step in the fitting procedure is to measure the person sitting on a plain flat bench.
- This provides a set of starting measurements of the person's body that we can transfer to the rig.
- We're cautious to make absolutely clear to the person we're fitting that this is only a preliminary setting or starting point.
- We have found if we don't emphasize this point, frequently people will refrain from telling us that the seat-to-back angle's too acute or the thoracic support is too low.
- We try to loosen them up and get them involved in the fitting procedure.

Measurement

- The first measurement, known as the popliteal, is taken by measuring from the floor to the underside of the thigh at the knee.
- The customer should have on the same shoes that will typically be worn when sitting in the chair.
- Then we measure from that same point in the crook of the knee to the surface of the back.
- Afterward, holding a yardstick in contradiction of the person's back with the end of the yardstick on the bench, we measure the height of the waist.
- We determine the place of the waist by having the customer bend to the side while seated.
- As it turns out, if you carry the waist measurement around to the back, that's just about where most people like to feel lumbar support.
- We measure from seat to elbow to determine armrest height and note the relaxed spread of the arms as well for the width of the armrest at the elbows.
- The angle of the armrest is less predictable, we've found, so we just experiment until we hit upon a comfortable angle.
- Afterward, we measure from the seat to the underarm.
- This measurement is required for dining chairs in particular since

it tells you approximately where to position upper back support.

- Just as a dining chair requires upper back support, each type of chair has its own special traits and requirements.
- All chairs need to be wide enough in the seat to get in and out of, so we take a seated hip width measurement; shoulder width isn't that significant a measurement unless you are building a chair that will partially envelop its owner, such as a large stuffed chair or recliner.
- Nevertheless, while we're measuring, we get all the information we can; there's no telling when a client we're fitting for a reading chair will want to order a set of dining chairs.
- The final two vertical measurements that we take are from the seat to the nape of the neck and from the seat to the back of the head.
- These measurements are most critical for a chair intended mostly for relaxing in, where head support is absolutely essential.
- Afterward, with the yardstick, or some other straight edge still in place in contradiction of the person's back and the person sitting up straight, we measure the horizontal distance from straight edge to lumbar, waist measurement transferred to the back, then from straight edge to the juncture of head and neck, the nape and last, from straight edge to the back of the head.

How to adjust the rig

- Setting the rig is straightforward once we've got all the above measurements.
- The measurements and angles vary for different kinds of chairs, but for the sake of explanation, let's presuppose we're designing a reading chair.
- We set the seat depth first to about 2 in. less than the measured under-thigh distance and then set the seat height at the knee to about 3 in. less than the popliteal measurement.
- We drop the rear of the seat 3 in. from the front setting, or 5 in. from the popliteal.
- We set the arm width at the elbow. Afterward, and this generally falls in a fairly narrow range amongst 21 in. and 23 in. and then set the arm height at the elbow about 1 in. to 2 in. greater than the seat to elbow measurement.
- For this preliminary setting, we position the back at 105 degree to the seat.
- Since we're adjusting the rig to fit the customer, this seat to back angle will frequently change.
- If we run out of range as we're adjusting the settings of the back supports, we can change the seat-to-back angle.
- We adjust all the back supports used of the measurements just taken, beginning with the sacral; 1 in. forward of the back rail, 3 in. up from the seat.
- Proceeding up the back, we adjust the lumbar support-perhaps the most vital, which is typically 8 in. to 10 in. up, 1 in. to 2 in. forward of the back rail, thoracic support set at the height of the underarm, at the same distance from the back rail as the sacral adjustment, and lastly, the neck and head supports.
- These last adjustments vary widely, and a survey of various customers revealed a vertical range of 14 in.
- From this point on, it's really just a question of use of your common sense and making increasingly finer adjustments.
- The chair's intended use, how it will relate to other furnishings such as a dining or end table, and whether the chair's owner wears heels, flats, sneakers or is barefoot.

- All these need to be measured when translating the information gathered on the rig into a chair design.
- When we schedule a fitting, we encourage the customer to bring whatever is necessary to make the fitting absolutely realistic.
- That might mean a pair of slippers and a book or a newspaper-or even a bowl, spoon, box of corn flakes and a quart of milk.
- Pretending to eat a bowl of cereal while reading the paper just isn't the same as essentially doing it, and we want the chair to be comfortable in use.

BOOK 4

17

PROJECTS AND PRACTICAL TECHNIQUES
YOU SHOULD APPLY

Paul Berger

Chapter 1 – Overview of Outdoor Tables

Eating outdoors is one of life's modest pleasures. Whether it's a picnic, a barbeque, or something more elaborate, dining al fresco always adds something special to the involvement.

The patio table and the folding picnic table in the following chapters are both excellent additions to any outdoor furniture ensemble. The patio table is large enough to seat six adults comfortably.

It is, in fact, as big as numerous dining tables. The table does not seem imposing, Nevertheless mainly as of the lattice-work grid that comprises the top. This gives the table a light appearance, and literally decreases the weight.

While it is not as portable as the picnic table, it can be moved simply by two people, or even one in a pinch. Like numerous pieces of outdoor furniture, the patio table relies on half laps to join the legs and rails.

The frame surrounding the lattice grid is assembled with bridle joints. These robust joints help make up for some of the rigidity sacrificed by having a lattice top instead of a solid one.

The grid itself is formed by joining the strips of wood with half-lap joints. This calls for cutting several hundred dados-a daunting task, but one made quite manageable with the help of the indexing jig.

The folding picnic table (will be discussed later) offers a convenient solution to the need for a table that is transportable. It is intended to fold down neatly and can fit inside most car trunks. When locked in the up position, the table provides a sturdy exterior large enough to seat four adults.

Its building combines the usage of pre-fabricated parts and building to fit. While the top can be made by referring only to the requirements listed, the legs must be planned cautiously so they nest inside each other and must be trimmed to the right length and angle as the last step.

A useful companion to both tables is the keyed tenon bench. It is eye-catching, modest, and exceedingly robust. Occasionally called a joynt stool, this is a very old design that could have been found outside an English cottage four hundred years ago. Nevertheless, it looks perfectly at home on a contemporary deck or patio. Its modest design makes it easy to build to whatever length you need.

Chapter 2 Patio Table

The patio table is a fairly formal, but welcome addition any deck or backyard. The lattice grid lends a light ness to a fairly large table. A clever design element holds the grid in place with no need to cut a surrounding rabbet.

The inside length and width of the frame are 1 ½ inches longer than those of the table base. This creates a ¾ inch ledge to hold the grid on top of the rails, within the frame.

The grid itself can be assembled on the workbench and then installed in the table. Prepare the strips one inch longer than cited in the requirements listed, cut the dados for the half-laps, and then trim them to fit.

While it will hold up to reasonable use, but do not expect it to withstand the same stress as your oak dining table. The grid of lattice strips lacks the same strength and rigidity as a solid top. To increase the top's resistance to racking, the curves are joined with bridle joints, which offer twice the gluing exterior of half-laps.

Requirements:

- *Legs: Quantity: 4, Thickness: 1 1/2 inches, Width: 3 ½ inches, Length: 29 inches*
- *Side rail: Quantity: 2, Thickness: 1 1/4 inches, Width: 4 ¼ inches, Length: 55 ½ inches*
- *End rails: Quantity: 2, Thickness: 1 1/4 inches, Width: 4 ¼ inches, Length: 30 ½ inches*
- *Frame sides: Quantity: 2, Thickness: 1 1/4 inches, Width: 3 inches, Length: 60 inches*
- *Frame ends: Quantity: 2, Thickness: 1 1/4 inches, Width: 3 inches, Length: 36 inches*
- *Short lattice strips: Quantity: 24, Thickness: 3/4 inches, Width: 1 ¼ inches, Length: 29 7/8 inches*
- *Long lattice strips: Quantity: 13, Thickness: 3/4 inches, Width: 1 ¼ inches, Length: 54 inches*

How to assemble the legs and the stretcher

1 – How to cut half-laps

- The rails should be joined to the legs with half-laps.
- Start with the side rails and the legs.
- Install a dado head on your table saw and set the cutting height to half the thickness of the stock.
- Adjust the fence to make a 3 ½ inch-long rabbet, and then add an extension board to your miter gauge.
- Cut the rabbets in the side rails and the outside faces of the legs.
- Afterward, hold the leg on edge opposed to the miter gauge extension and cut the dado in the outside edge to accommodate the end rail.
- To prepare the end rails, shift the fence for a 1 ½ inch long rabbet, then make the cut on the inside faces of the end rails.
- The final step is to trim 5/8 inch from each end of the end rails.
- This will allow the end rails to sit flush opposed to the legs.

2 – How to make pocket holes

- Utilize a commercial pocket hole cutter to make the pocket holes.
- The jig should consist of two pieces of ¾ inch plywood joined to form an L-fashioned cradle and two support brackets that angle the cradle at 15 degree from the vertical.
- Seat the work piece in the cradle, and align the stock so the clearance hole will exit in the middle of the board edge.
- Install a Forstner bit and drill a hole just deep enough to recess the screw head.
- Then install a brad-point bit and bore the clearance hole through the work piece.

3 – How to attach the legs

- Set one pair of legs on a work exterior and apply glue to the rabbets.
- Slide a side rail in position and secure it with a screw at each end.

- Confirm for squareness and adjust as necessary, then add two more screws.
- Repeat the procedure for the other leg and for the second pair of legs.

4 – How to add the end rails

- To attach each end rail, drill clearance holes in each end then apply glue to the rabbets.
- With the help of an assistant to hold up the sides on a level exterior, position one of the rails and screw it in place with one screw.
- Confirm to ensure that it is square and then add another screw.
- Repeat the procedure for each corner.
- Confirm the table base for square by taking a measurement across each diagonal; they should be equal.
- If not, place a clamp over the longer diagonal and tighten it slowly until the two distances are equal.
- Leave the clamp in place until the glue cures.
- If you have to make corner half-laps in several boards of the same size, it is worth taking the time to build the jig.
- Cut the two base pieces and the stop block from plywood the same thickness as your stock.
- The base pieces should be wide enough to accommodate the edge guides and support the router base plate as you cut the half-laps.
- Utilize solid wood strips for the four edge guides.
- To assemble the jig, mark the shoulder of the half-lap on one work piece and set the board face-up on a work exterior.
- Butt the base pieces opposed to the edges of the board so the shoulder mark is near the middle of the base pieces.
- Install a straight bit in the router and align the cutter with the shoulder mark.
- Position one end guide across the base pieces and opposed to the tool's base plate.
- Without moving the work piece, repeat the procedure to position the opposite guide.
- Now align the bit with the edges of the work piece and attach the

side guides, leaving a slight gap amongst the router base plate and each guide.

- The first half-lap you make with the jig will rout reference grooves in the base pieces.
- Slip the stop block under the end guide, butt it opposed to the end of the work piece, and screw it in place.
- Countersink all fasteners.
- To utilize the jig, clamp it to the work exterior and slide the work piece amongst the base pieces until it butts opposed to the stop block.
- Protecting the stock with a wood pad, clamp the work piece in place.
- Adjust the router's cutting depth to one-half the stock thickness.
- Then, with the router distance inside the guides, grip the tool firmly, turn it on, and lower the bit into the work piece.
- Guide the router in a clockwise direction to cut the outside edges of the half-lap, keeping the base plate flush opposed to a guide at all times.
- Then rout out the enduring waste, feeding the tool opposed to the direction of bit rotation.

How to prepare the lattice frame

1 – How to cut tenon cheeks

- The curves of the lattice frame are joined with bridle joints for extra strength.
- The first step is to cut the tenon cheeks.
- If you are working with a table saw you will need a commercial tenoning jig or a shop-built device.
- To cut the cheeks set the saw blade to its maximum height and mount the end of the frame in the tenoning jig.
- Adjust the jig so the blade meets the board at one third of the stock's thickness from the edge.
- Keen the kerf on the waste side.
- Turn on the saw and make a pass through the blade.
- Afterward, flip the board around and make the second cut.
- Repeat for the opposite end then cut the cheeks in the other frame end.

2 – How to cut the shoulders

- Once all the tenon cheeks have been cut, trim off the waste on the table saw to make the shoulders.
- Lay the frame rail on the table and adjust the blade height so it just touches the cheek.
- Attach an extension to the miter gauge.
- Hold the rail opposed to the gauge and position the stock with the cutting mark for the shoulder in line with the blade.
- Clamp a stop block to the extension; this will speed up making repeat cuts.
- Then feed the stock into the blade.

3 – How to cut the mortise sides

- If your shop does not have a high ceiling you may not be able to cut the mortises in the stiles utilizing the table saw and the tenoning jig.

- Instead, saw them by hand.
- With a rail tenon as a guide, mark the shoulder line and the sides of the mortise on the edges and end of each stile.
- Then mount the stock on your workbench.
- This setup makes it easier to cut straight sides.
- With a back saw, cut down from the corner, keeping the blade on both lines.
- Stop when the saw blade touches the shoulder line and the opposite corner.
- Cut its neighbouring side, then turn the board over and cut the other diagonal kerfs.
- Lastly, finish the sides by cutting straight down to the shoulder lines.

4 – How to chisel the mortise bottoms

- Eliminate the waste amongst the mortise sides with a mallet and chisel.
- Mount the stile to your work bench, clamping it firmly in place.
- Select a chisel the same width as the mortise, or as close as possible without being wider.
- To clean out the waste, place the chisel 1/8 inch in from the bottom of the mortise and tap it with a mallet so it sinks about 1/4 inch.
- Set the chisel back toward the end of the board by about ¼ and tap towards the first cut to eliminate a small notch of waste.
- Continue in this manner until you reach about half-way.
- Turn the board over and eliminate the rest of the waste.
- Lastly pare straight down at the shoulder line.

5 – How to attach the frame

- Once you have cut the bridle joints, dry assemble the frame and set it on the table base to ensure that it fits appropriately.
- There should be a ¾ inch ledge all around the inside edge of the frame, which will support the lattice grid.
- Disassemble the frame and spread some glue on the tenons.

- Reassemble the frame, confirm for squareness, and clamp each joint with a pair of clamps.
- Then round over the outside edges of the frame.
- To secure the frame in position, set it on the rails and arrange it to create an even 3/4 inch ledge.
- Hold the frame in place with a clamp in each corner and secure it with a screw in each pocket hole.
- You can utilize the jig to cut tenons on the table saw.
- Adapt the dimensions suggested to customize the jig for your saw, if necessary.
- Cut the jig fence and back from 3/4 inch plywood and saw a 45 degree bevel at one end of each board; the pieces should be wider than the height of your saw's rip fence.
- Fasten two pieces together face to face to fashion the back, then utilize countersunk screws to attach the fence and back in an L shape.
- Ensure the fasteners will not be in the blade's path when you utilize the jig.
- Afterward, cut the brace from solid stock, bevel its ends, and attach it flush with the top edges of the fence and back, forming a triangle.
- Make the clamp by face gluing two pieces of 3/4 inch plywood and cutting the assembly into the shape.
- Utilize a hanger bolt, washer, and wing nut to attach the clamp to the jig back, leaving a gap amongst the edge of the clamp and the fence equal to the thickness of the stock you will use.
- Offset the bolt so the clamp can pivot eccentrically.
- You can drill supplementary holes in the jig back so you can shift the clamp to accommodate different stock thicknesses.
- Afterward, cut the runner from solid wood.
- When attached to the jig fence, the runner will straddle the saw fence, eliminating any wobble.
- For some models, you will have to mill a groove down the length of the runner to fit the rip fence.
- Lastly, cut a piece of clear plastic as a blade guard and screw it to the jig back flush with its front face.
- To utilize the jog, set it on the saw table in front of the blade with

the runner and fence straddling the rip fence.

- Clamp the work piece in the jig and position the rip fence to align the cutting mark on the work piece with the blade.
- Feed the jig into the cutting edge.
- Your first usage of the jig will develop a kerf in the back.
- Flip the work piece around and repeat to cut the other cheek.
- Eliminate the jig to cut the shoulders.

How to assemble the lattice grid

1 – How to dado the cross strips

- The strips that make up the lattice grid are joined with half-lap joints-more than 300 in total.
- Position the dados with a modest indexing jig.
- Mount a $\frac{3}{4}$ inch-wide dado head on your table saw and adjust the blade height to half the width of the stock.
- Fix the jig to a miter gauge extension to leave 1 $\frac{1}{2}$ inch space amongst dados.
- Start with stock one inch longer and then the nominal lengths given in the cutting list.
- To cut the first dado in each piece hold it on edge opposed to the miter gauge with one end butted opposed to the key.
- Make a pass through the cutters, then move the board along the gauge, fitting the new dado over the key, and make another pass.
- Continue in this manner until you have cut dados in all the short and long strips.

2 – How to size the strips

- Both the long and short strips must be trimmed to fit inside the frame.
- Lay a short strip across the frame and adjust it until the distance amongst the last dado and the frame is the same on both ends.
- Make a mark on the strip.
- To trim the strip to this mark install a regular blade in your table saw.
- Afterward, reposition the miter gauge extension so that when the last dado is fitted over the key, the trimming mark is lined up with the blade.
- Trim the ends of this strip, and then trim both ends of all the short strips the same way.
- Repeat this procedure to trim the long strips.

3 – How to assemble the grid

- Assemble the grid, and then install it as one unit in the frame.
- Lay out all the short strips-dadoed edges up-on a large work exterior.
- Space them out by installing a long strip at each end.
- Afterward, install the rest of the long strips, applying glue first and working the dadoes together gently.
- Anchor each joint with a 1 inch galvanized common nail.
- Once all the long strips are in place, eliminate the outside long strips and reinstall them with glue and nail them in place.

4 – How to install the grid

- Pop the grid in place, and then turn the table upside down.
- Install angle brackets to secure the lattice in position.
- To ensure the grid rests flat, screw each bracket to the rails with a 1/8 inch space amongst it and the lattice strip.
- After attaching a bracket to its rail, secure it to the correcting lattice.
- The gap will cause the bracket to be cinched down on the lattice, holding it firmly.

Chapter 3 How to make a Foldable Picnic Table

Picnic table is great for spontaneous afternoons in the country. It folds down flat to fit into most car trunks or hatchbacks. The key to its portability is the U-fashioned leg assemblies, which nest inside each other.

To accomplish this, make the outer leg assembly first, and then cut the inner one to fit inside it. This arrangement means, nevertheless, that one leg rail is short, and must rest on a block to provide the appropriate table height.

The rail is held to the block with a butterfly catch. The leg ends should be marked and trimmed after the table is assembled, an easy way to get exactly the right angle and length.

The perfect complement to the picnic table is the keyed tenon bench. Also known as a joynt stool, it is an adaptation of an old English design that features an interesting building technique.

The legs are made in halves, and then joined with dowel joints to ensure symmetry, while the notches automatically form the through mortises to hold the stretchers in place.

Requirements for Picnic table:

- Outer legs: Quantity: 2, Thickness: 1 1/2 inches, Width: 3 1/2 inches, Length: 36 inches
- Inner legs: Quantity: 2, Thickness: 1 1/2 inches, Width: 3 1/2 inches, Length: 36 inches
- Hinge rail: Quantity: 1, Thickness: 1 1/2 inches, Width: 3 1/2 inches, Length: 36 inches
- Catch rail: Quantity: 1, Thickness: 1 1/2 inches, Width: 3 1/2 inches, Length: 29 inches
- Cross rail: Quantity: 1, Thickness: 1 1/2 inches, Width: 3 1/2 inches, Length: 29 inches
- Top rails: Quantity: 2, Thickness: 1 1/4 inches, Width: 4 inches, Length: 27 inches
- Top stiles: Quantity: 2, Thickness: 1 1/4 inches, Width: 4 inches, Length: 44 inches
- Butterfly catch support block: Quantity: 1, Thickness: 1 3/4 inches, Width: 4 3/4 inches, Length: 19 3/4 inches
- Top slats: Quantity: 7, Thickness: 1 1/4 inches, Width: 4 inches, Length: 48 inches
- Hinge supports: Quantity: 2, Thickness: 1 1/4 inches, Width: 3 inches, Length: 6 inches

Requirements for Bench

- Leg halves: Quantity: 4, Thickness: 1 1/2 inches, Width: 5 1/2 inches, Length: 16 inches
- Upper stretcher: Quantity: 1, Thickness: 1 1/2 inches, Width: 3 inches, Length: 28 1/2 inches
- Lower stretcher: Quantity: 1, Thickness: 1 1/2 inches, Width: 3 inches, Length: 34 inches
- Cleats: Quantity: 4, Thickness: 1 1/2 inches, Width: 1 1/4 inches, Length: 4 7/8 inches
- Seat slats: Quantity: 3, Thickness: 1 1/2 inches, Width: 4 3/4 inches, Length: 36 inches
- Tusks: Quantity: 2, Thickness: 1 1/2 inches, Width: 1 inches, Length: 4 inches

How to assemble the top

- Cut the top slats to size according to the requirements and round over their top edges and the ends.
- The top slats are secured to a rectangular frame which also holds the leg assemblies.
- Cut the frame's stiles and rails to size, and then cut rabbets in their ends for the half-lap joints. Glue the frame together and fasten it with screws.
- Confirm for squareness.
- To assemble the top, lay out the top slats on a work exterior separated by 1/4 inch spacers.
- Hold them together with a bar clamp at each end.
- Center the frame on the top, confirming with a measuring tape that the borders along the sides and the ends are even.
- Secure the frame with a pair of screws into each slat.
- Do not utilize any glue here, so it will be a modest matter to replace broken or rotten slats in the future.

How to make the leg assemblies

1 – How to prepare the leg pieces

- Cut the legs and joining rails to size then cut the rabbets for the half-laps in the legs and the rails.
- Afterward, mark out a 3 ½ inch dado for the cross rail on the inner legs, starting 21 inches from the top.
- To make the dados, make two passes, cutting out the extremes of the dado, then eliminate the rest of the waste.

2 – How to fasten the legs and rails

- Starting with the outer leg assembly, lay the legs on a work exterior and apply glue to the rabbets.
- To attach each rail, place it in position on the legs and secure it with one screw at each end.
- Confirm that it is perfectly square, and then add the second screw.
- Prior to assembling the inner legs and rails, double confirm that the rails will fit inside the outer assembly, otherwise the legs will not fold appropriately.
- If necessary, trim the rails and adjust their rabbet to compensate.
- Assemble the inner legs, then add the cross rail.

3 – How to round over the legs and rails

- Round over the legs and rails after they have been assembled.
- Set the depth of cut to eliminate the waste in two passes.
- Clamp the assembly to a work exterior.
- Turn on the router and ease the bit into the wood until the bearing touches, then work the router around the work piece, making sure that you move opposed to the bit's direction of rotation.
- Reposition the clamps as necessary.
- Then round over the other leg assembly.

4 – How to fit the carriage bolts

- Set the two leg assemblies on a work exterior, with the smaller one nested inside the bigger one, and then clamp them to the table.
- Mark the holes for the bolts on both assemblies, 18 inches from the top of the hinge rail.
- Fit a drill with a 5/16 inch bit, and then bore the hole, keeping the bit perfectly perpendicular to the edge.
- It helps to have an assistant sight the bit to keep it level.
- Drill as deep as you can, then finish from the other side.
- Tap the carriage bolts through the legs with a hammer, then slide on a washer.
- Hand tighten two nuts, then fit a wrench on both nuts and hold the inner one in place while tightening the outer one opposed to it.

How to install the legs

1 – How to attach the hinges

- Screw the hinge support to the underside of the table top where the rails and stiles meet.
- Then position the outer leg assembly on the top stile and hold it upright with a hand screw.
- Arrange the assembly so the hinge will be 3 5/8 inches from the outside edge of the stile.
- Then screw the hinge to the leg prior to attaching it to the table top.

2 – How to add the butterfly catch support block

- Cut the block to size according to the cutting list, ripping one edge at 30 degrees, leaving a 4 inch-high outside face.
- Saw the opposite face of the block at 60 degrees.
- Apply glue to the table where the block will touch it and clamp the block securely.
- Drill a pilot hole every 4 inches, then screw the block in place.

3 – How to install the dowels

- To bolster the union amongst the butterfly catch support block and the edge of the catch rail install a pair of ½ inch dowels.
- To fit the dowels, first drill two ½ inch holes in the block, perpendicular to the angled face, to a depth of about ¾ inch.
- Place dowel centers in the holes and bring the catch rail into position.
- Push down on the rail to mark the dowel holes.
- Drill 1-inch-deep holes in the rail.
- Spread glue inside the block holes and tap two 1 ½ inch long dowels into place.
- Then screw the butterfly catch to the rail and support block.

How to fit the legs

1 – How to mark the legs

- The position of the legs makes it hard to mark their length so they will sit perfectly level with the help of a tape measure.
- One trick is to trim a piece of scrap plywood to a width of 28 inches and utilize that as a guide.
- To mark the inner legs, clamp a carpenter's square to the guide to hold it upright and set it opposed to the leg.
- Hold a try square opposed to the board and mark the cut off length and angle.
- To mark the outer legs, it is possible to simply hold the marking board opposed to the leg edge and trace the line.
- With the try square run the lines around all four sides of each leg.

2 – How to trim the legs

- To trim each leg, mount it in a vise and cut it off with a backsaw, keeping the saw both on the top edge line and the line on the closest face.
- Once the kerf extends across the top edge continue cutting straight down.
- Keep confirming both lines to ensure the saw does not wander.

3 – How to finish a rounding feet

- Every time the table is moved, you risk catching an edge and splintering the bottom.
- To prevent this, round over the bottoms of the legs with a random orbit sander or a sanding block.

Chapter 4 How to make a Joynt Stool

The joynt stool, also known as keyed tenon bench, is a handy seat that can be

made in almost any length. It is the perfect complement to the picnic table but is useful all by itself.

How to make the legs

1 – How to mark the leg boards

- The leg boards are made in halves, and then glued together with dowel joints.
- Prepare the legs according to the requirements.
- Confirm that the notched edges are perfectly straight so they will form a tight glue joint.
- Set the template on the leg stock and mark out the curve and the notches.

2 – How to cut the leg boards

- Cut out the less on the band saw.
- Start with the curve, simply cutting on or just outside the marked line.
- To cut out the notches, first make a short cross-grain cut to define the mortise end.
- Afterward make a sweeping cut towards, then along, the mortise side line until you reach the other cross grain mark.
- Cut this section free.
- Lastly reorient the board and eliminate the rest of the waste.
- Sand off any machining marks from the curve.

3 – How to join the leg halves

- Join the leg halves with dowel joints.
- To prepare the legs for the dowels, drill two ½ inch diameter holes, 1 inch deep into one half.
- Mark the opposite legs with dowel centres.
- Position the tops of the legs opposed to a straight edge such as a rip fence to ensure the notches will line up.
- Spread some glue inside the holes and along the straight edges of the legs.

- Push the two halves together and clamp the leg with a bar clamp opposite each of the two glued edges.

How to assemble the bench

1 – How to cut tenons in the stretchers

- Prepare the stretchers referring to the requirements, and then rabbet their ends to make the tenons.
- The top stretcher tenon should be 1 ¼ inches long to end flush with the legs, while the lower one must be 4 inches long to allow it to hold a tusk pin.
- To cut the rabbets, install a dado cutting assembly in your table saw and attach a miter gauge extension.
- Adjust the cutting height to about ¼ inch and make a cut in both sides of a piece of scrap stock and test the fit in the open mortise.
- Fine tune the height until the test tenon fits snugly.
- Set the rip fence to make a 1 ¼ inch-long tenon.
- To cut the tenon, hold the stock opposed to the miter gauge extension with an end butted opposed to the fence.
- Pass the wood over the cutters, and then eliminate the rest of the waste by moving the work piece away from the fence in successive passes.
- Repeat for the other side and the opposite end.
- Afterward, raise the cutters to ½ inch, hold the stretcher on its lower edge, and cut a notch to allow the stretcher to fit flush with the top of the legs.
- Rearrange the fence to make a 4 inch-long tenon and make the cut in the lower stretcher.
- Then saw a ¼ inch notch in the top and bottom edges to allow the piece to fit into the mortise.

2 – How to install the stretchers

- Install the lower stretcher first.
- To prepare the tenon for the tusk pin, bore a 1 inch-diameter hole centered 2 ¼ inches from the tenon end.
- Then insert the stretcher in the leg.
- Do not press down on the outside edges of the legs to force them over the tenon; this is liable to split them.

- Instead, knock the leg on both sides of the tenons with the heel of your hand.
- When the stretcher is in place, the tenon should reveal a ½ inch semicircle to hold the tusk.
- Whittle and sand the tusk stock so it fits firmly in the opening.
- Make it fairly wedges fashioned so it tightens the joint the further it is inserted.
- Tap the tusk in place with a mallet.
- Lastly, apply glue to the upper mortise and slide the too stretcher in place.

3 – How to attach the seat support cleats

- To avoid having screw holes in the top of the seat, secure the slats to the legs with cleats.
- Trim the cleats they fit on either side of the top stretcher.
- Drill the pilot holes for attaching the slats off center to make it easier to tighten the screws into the seat without knocking your hands opposed to the legs.
- Apply glue to the cleats, and then secure them to the legs with screws so the strips are flush with the top of the legs.

4 – How to secure the slats

- Round over the top edges of the slats, then lay them out on a work exterior, separated by ¼ inch spacers.
- Ensure the ends are all even, then tighten a bar clamp across each end to hold the slats in place.
- Center the bench base on the slats and secure it with screws.

Chapter 5 Overview of Outdoor Chairs

Outdoor furniture must be intended to rough it, and the Adirondack chair, chaise lounge, and curved chair featured in the following chapters are all up to the task. In numerous parts of the country with harsh winters, the appearance of outdoor chairs marks the return of pleasant weather.

Carted out of the garage or basement on the first sunny day of spring, given a quick dusting off, and then left exposed to the elements, they must withstand rough use, indeed, until they are returned to shelter after the first frost.

Such treatment places a particular set of demands on the joinery. The blind mortise-and-tenon, for instance, which is typically an excellent choice to join chair parts, does not fare so well with outdoor furniture, since the mortise serves as a convenient trap for water.

Even with a durable and decay-resistant species, there is the danger that the wood will ultimately rot. All three chairs in the following chapters solve this issue by utilizing half-lap joints.

What it lacks in stoutness, the half-lap makes up for in versatility. It will not trap water and, when reinforced with a weather proof epoxy and screws, it is extremely robust. The joint is also fairly modest to develop.

You can make both parts of the connection on the table saw. If you need to cut a series of half-laps, it will perhaps be worth your time to make a shop-built jig and do the job with a router.

The chaise lounge relies heavily on the half-lap. The joint is used to fasten all the back slats to the rails. The back of this classic poolside relaxer can assume six different positions, from the horizontal to nearly vertical.

The curved chair is an original design, ideally suited for a hidden corner of the garden. Assembled with a number of identical units tied together by a length of threaded rod, the chair derives its gentle curve from circular spacers that hold the units farther apart at the back than at the front.

The version discussed in this book is made up of eight units; you can build a wider chair, or even a bench, by incorporating more units in the design.

There are few pieces of outdoor furniture more inviting than an Adirondack chair. Its reclining seat and tilted backrest beckon the user to sink into the

seat and lean back, elbows propped on the wide armrests which provide plenty of room for books and a cold drink.

Most of the parts of the chair are irregularly fashioned. To redevelop the classic design, confirm the requirements. Recall that the dimensions cited in the cutting list represent the stock size prior to shaping on the band saw. Size the parts first, and then transfer the patterns to the stock.

Requirements:

- Arm: *Quantity: 2 Thickness: 3/2 inches, Width: 5 ½ inches, Length: 29 inches*
- Arm brace: *Quantity: 2, Thickness: 1 1/4 inches, Width: 3 inches, Length: 10 ½ inches*
- Leg: *Quantity: 2, Thickness: 1 1/4 inches, Width: 3 ½ inches, Length: 21 ½ inches*
- Side rail: *Quantity: 2, Thickness: 1 1/4 inches, Width: 5 ½ inches, Length: 30 ¾ inches*
- Apron: *Quantity: 1, Thickness: 3/2 inches, Width: 5 ½ inches, Length: 21 ½ inches*
- Back cleat: *Quantity: 1, Thickness: 1 1/4 inches, Width: 3 ½ inches, Length: 21 ½ inches*
- Center back slat: *Quantity: 1, Thickness: 3/2 inches, Width: 5 ½ inches, Length: 35 inches*
- Side back slats: *Quantity: 4, Thickness: 3/2 inches, Width: 3 ½ inches, Length: 35 inches*
- Back support: *Quantity: 1, Thickness: 1 1/4 inches, Width: 3 ½ inches, Length: 28 inches*
- Batten: *Quantity: 1, Thickness: 3/4 inches, Width: 3 ¼ inches, Length: 19 ½ inches*
- Seat slat: *Quantity: 5, Thickness: 3/4 inches, Width: 3 ¼ inches, Length: 21 ½ inches*

Chapter 6 How to build an Adirondack Chair

How to prepare the stock

- Cut the pieces of the chair to size.
- For the back slats, start by tapering them so the middle one is 4 5/8 inches wide at the bottom and 5 1/2 inches at the top; the outside slats should be 2 1/2 inches at the bottom and 3 1/2 inches at the top.
- You can make the cuts on a table saw utilizing a commercial jig or the shop-built version.
- Afterward, set the slats edge to edge on a work exterior; the ends will be uneven.
- To even out the bottom edge, utilize a pencil and a carpenter's square to mark a line across the outside slats that aligns with the end of the middle piece.
- Trim the outside slats along the marks, and then draw a line down the center of the middle slat.
- Reposition the slats and clamp them together with their bottom ends aligned and 1/4 inch-thick spacers amongst the pieces.
- Adjust a compass to a 16 inch radius, set the point on the middle slat centreline 18 3/4 inches from the bottom end, and draw the curve at the top end of the slats.
- Cut the slats on your band saw, then round over their edges.
- To taper the back slats and legs of your chair on the table saw, build the jig from 3/4 inch plywood.
- To assemble the jig, set the saw blade to its maximum height, butt one side of the jig base opposed to the blade and position the rip fence flush opposed to the other side of the base.
- Lower the blade.
- Mark a cutting line for the taper on the work piece, then set it on the base, aligning the line with the edge of the base nearest the blade.
- Holding the work piece securely, position the guide bar opposed to the edge and the stop block snugly opposed to the end.
- Screw the guide bar and stop block to the base and press the toggle clamps down to secure the work piece to the jig; protect the stock with wood pads.

- To make the cut, set the blade height and slide the jig and work piece across the table, making sure that neither hand is in line with the blade.

How to assemble the chair

1 – How to attach the side rails to the legs

- To position the side rails on the legs, mark a pair of intersecting guidelines on the legs' inside faces.
- Mark one line parallel to the front edge and 1 inch from it to allow for the apron and a $\frac{1}{4}$ inch reveal; the second line should be parallel to the top end and $6\frac{3}{4}$ inches below it.
- To ensure the leg and rail will be level on the ground, align the bottom ends of the pieces with an edge of your work exterior; utilize a try square to ensure the front edge of the leg is perpendicular to the edge of the table.
- Drill three clearance holes for screws through each rail and spread waterproof glue on the contacting exteriors amongst the leg and rail.
- With the leg inside-face up on a work exterior, fasten the rail to the leg, aligning the front end and top edge of the rail with the guidelines on the leg.

2 – How to install the apron

- Bore three clearance holes through the apron about $\frac{5}{8}$ inch from each end.
- Apply waterproof glue to the ends of the rails, set the legs upright on a work exterior and position the apron amongst the legs and flush opposed to the rails.
- The top edges of the apron and rails should be level.
- Utilizing a bar clamp to hold the piece square to the legs, screw the apron to the rails; protect the stock with wood pads.

3 – How to attach the back cleat to the side rails

- Recall to round over the top edges of the cleat prior to installing the piece.
- Then mark a guideline for the cleat across the top edge of each rail $11\frac{1}{2}$ inches from the back end.

- Drill two clearance holes through the cleat near each end, spread glue, and utilize a clamp to hold the cleat in position opposed to the rails.
- Making sure the ends of the cleat are flush with the outside edges of the rails, fasten the piece in place.

4 – How to screw the arm brace to the legs

- Clamp each arm brace to its leg and side rail so it is aligned with the middle of the leg.
- The top ends of the brace and leg should be flush.
- Afterward, bore three clearance holes through the leg, stopping the drill when the bit contacts the brace.
- Install a smaller-diameter bit to continue drilling pilot holes into the brace, utilizing the clearance holes as guides.
- Unclamp the brace, and then spread glue on its flat edge, re-clamp it in position, and fasten it to the leg.

5 – How to prepare the back support

- Bevel the front edge of the back support to provide an adequate bearing exterior for the back slats and allow them to tilt at the correct angle.
- On your table saw, position the rip fence on the left-hand side of the saw blade for a width of cut of $2 \frac{5}{8}$ inches and angle the blade to 30 degree.
- It is always safest to make a bevel cut with the blade angled away from the fence.
- Feed the stock into the cutting edge with your left hand while pressing the board opposed to the fence.
- Finish the pass with a push stick.
- Afterward, outline the curves on the outside edge of the back support one at each end and mark a straight line across the board $3 \frac{3}{4}$ inches from each end.
- Utilize your band saw to make a cut from each end of the support to the straight line; align the cuts with the start of the bevel.
- Lastly, cut the curved ends of the board on the band saw.

6 – How to attach the arms to the back support

- Recall to round over the arms, and then drill two clearance holes through each one.
- Spread waterproof glue on the mating exteriors of the arms and support, position one of the arms on the support, and screw the pieces together, utilizing a try square to ensure the pieces are perpendicular to each other.
- Repeat to fix the other arm to the support.

7 – How to install the middle back slat

- Prior to you can attach the arms and back support to the chair, the middle back slat must be fastened in place.
- Set the chair upright on a work exterior and clamp the slat to the center of the back cleat, aligning the bottom end of the slat with the bottom face of the cleat; protect the stock with wood pads.
- Holding the slat flush opposed to the cleat, utilize three screws to fasten it in place.
- Do not utilize glue in case you need to adjust the slat later when you install the remaining back slats.

8 – How to fasten the arms and back support to the chair

- Set the arms and back support upside down on a work exterior, then position the leg assembly on the arms.
- Center the middle back slat on the back support and clamp the pieces together.
- At the front of the chair, utilize a tape measure to ensure that the inside edges of the arms extend beyond the legs by the same amount on both sides.
- Utilizing the legs and arm supports as guides, make place marks on the undersides of the arms once you are satisfied with the position of the leg assembly.
- Set the chair upright and drill three clearance holes through each arm and one through the middle back slat.
- Spread glue on the contacting exteriors of the arms, legs, and arm

supports, then reposition the arms in place-utilizing the place marks as guides and screw the pieces together.

9 – How to fasten the back slats

- Spread glue on the contacting exteriors amongst the side back slats and the back support and cleat.
- Screw the slats in place, slipping ¼ inch spacers amongst the pieces to position them appropriately.
- Utilize two screws to secure each slat to the cleat and a single fastener at the back support.
- Ensure the bottom of each end slat is flush with the bottom edge of the cleat.
- Once all the side slats are installed, unscrew the middle one, apply glue, and reattach it.

10 – How to install the batten

- To cut the batten to final length, clamp your stock opposed to the back slats about 12 inches above the back support and mark the outside edge of the slats on the board.
- At the same time, mark clearance holes on the batten two for each slat-alternating the holes amongst the top and bottom edge of the stock.
- Cut the batten to length on your band saw and drill the clearance holes.
- Then, spread some glue on the batten, clamp it to the back slats, and screw it in place.
- Utilize a belt sander to create a smooth curve along the top of the back slats and sand the ends of the batten and the joint amongst the arms and the back support.

11 – How to attach the seat slats

- To complete the chair, round over the edges of the seat slats, then drill two clearance holes at each end of the pieces.
- Starting with the slat nearest the back, spread some glue on the

slat's bottom face and screw it to the side rails; utilize $\frac{1}{4}$ inch spacers to maintain the appropriate gap amongst the slat and the back.

- Install the enduring slats the same way, separating the pieces with the spacers.
- The last slat should extend beyond the apron by about 1 inch.
- Rip the slat to width and round its edges again, if necessary, prior to screwing it in place.

Chapter 7 How to make a Curved Chair

The curved chair I will discuss in this chapter is built by joining eight identical H-fashioned units with steel rods. Each unit is separated from the adjoining one by three 2 inch diameter spacers two at the rear leg and one at the front.

The curve is achieved by utilizing 1 ½ inch-long spacers in back and ¾ inch-long spacers in front. The modular design of the chair is very versatile. You can utilize spacers of uniform length to create a straight chair or build supplementary units to make a bench.

Each seating unit is joined to its rear and front legs with half laps a T half-lap at the back and a corner half-lap at the front-and all the joints are reinforced by screws. Once the joinery is done, the pieces are fashioned and trimmed with a router and a template.

Requirements:

- *Rear leg: Quantity: 8, Thickness: 1 1/4 inches, Width: 5 ½ inches, Length: 36 inches*
- *Front leg: Quantity: 8, Thickness: 1 1/4 inches, Width: 5 ½ inches, Length: 17 ¾ inches*
- *Seating unit: Quantity: 8, Thickness: 1 1/4 inches, Width: 4 7/8 inches, Length: 20 ½ inches*
- *Long spacers: Quantity: 16, Thickness: 1 1/2 inches, Width: 2 inches*
- *Short spacers: Quantity: 8, Thickness: ¾ inches, Width: 2 inches*
- *Caps: Quantity: 6, Width: 1 inches*
- *Rods: Quantity: 3, Width: 1/4 inches, Length: 36 inches*
- *Washers: Quantity: 6, Width: ¼ inches*
- *Nuts: Quantity: 6, Width: ¼ inches*

How to assemble the units

1 – How to make the template

- Mark out a template of the chair units on a piece of plywood or hardboard, referring to the requirements.
- Start by drawing the legs and seating unit with straight lines, and then utilize a thin strip of springy wood to help you outline the natural curves along the edges of the pieces.
- Utilizing a hand screw and a bar clamp, secure the strip on edge on the template so that one face is flush with the top of one of your cutting lines.
- Then gently bend the strip toward the other end of the line.
- Keeping the strip firmly in place, run a pencil along it to define the curve.
- Cut the template to shape on your band saw, and then sand the edges smooth.
- Set the template aside for now; prior to utilizing it to outline and trim the units, you need to cut the half laps in your stock and assemble the pieces.

2 – How to cut the half-laps in the front legs and seating units

- Mark the shoulders of the half-laps on your blanks for the front legs and seating units, utilizing the template as a guide.
- Then install a dado head on your table saw, adjust it to maximum width and set the cutting height at one-half the stock thickness.
- Attach an extension board to the miter gauge, align the shoulder line on the first leg with the blade and clamp a stop block to the extension opposed to the end of the work piece.
- Starting at the end of the board, feed it face down along with the miter gauge to saw away the waste.
- Make a series of passes to eliminate the enduring waste wood until you define the shoulder with the work piece butted opposed to the stop block and miter gauge extension.
- Repeat with the enduring front legs, and then cut half laps at both ends of the seating units the same way, repositioning the stop

block as necessary.

3 – How to saw the dados in the rear legs

- Outline the dados in the rear leg blanks to accommodate the half-laps in the seating units.
- The same setup used to cut the half-laps can be employed to saw the dados-except that you will need to clamp a second stop block to the miter gauge extension to set the overall width of the joint.
- Feeding the work piece face down and butted opposed to a stop block, start by cutting the two sides of the dado.
- Then make a series of passes to clear the waste in amongst.

4 – How to assemble the units

- Test fit the legs and seating units, and utilize a chisel to trim any ill-fitting joints.
- Then drill two clearance holes into the stock at each joint and spread water proof glue on the half-laps of the seating units; ensure to locate the screws so they will not interfere with the placement of the threaded rod.
- Clamp the rear leg face up to a work exterior, position the seating unit on it, and screw the pieces together.
- Note that the back end of the seating unit is offset from the back edge of the leg; about one-half the width of the legs will be cut away at the point where they meet the seat.
- Lastly, attach the front leg to the seating unit.

How to trim the units to size

1 – How to outline the chair profile on the units

- Once all the units are assembled, place one face up on a work exterior, position the template on it, and utilize a pencil to trace its outline on the stock.
- The back edge of the template should be almost flush with the back edge of the rear leg at its top end.
- Mark the enduring units, then cut them all to rough size on the band saw, leaving about 1/8 inch of waste outside your cutting lines.

2 – How to shape the chair units

- Finish shaping the units utilizing a router fitted with a top-piloted flush rimming bit.
- Set the unit on a work exterior and center the template on top, then fasten the pieces together, driving a screw through each threaded rod hole in the template into the unit.
- Clamp the assembly to the table and adjust the router's depth of cut so the pilot bearing will rub merely on the template.
- Guide the router opposed to the direction of bit rotation along the edges of the unit, keeping the bearing in continuous contact with the template.
- Reposition the clamps as required.

3 – How to round over the end units

- To round over the outside edges of the two units that will be on the outside of the chair, install a bottom-piloted rounding over bit in the router and set the depth of cut to reach your final depth in two passes.
- Secure the unit outside-face up to a work exterior and make each pass by feeding the router along the edges of the piece, pressing the bit's pilot bearing opposed to the stock throughout.
- Again, reposition the clamps as necessary.

How to Assemble the Chair

1 – How to prepare the units I for the threaded rod

- Utilize the holes you used to secure the template as guides to bore clearance holes for the threaded rod.
- Start by clamping a plywood backup panel to your drill press table and install a $\frac{1}{4}$ inch bit in the machine.
- Position the unit on the table so that one of the holes is aligned under the bit and hold the unit steady as you drill the hole.

2 – How to make the spacers

- Fit your drill press with a $1\frac{3}{4}$ inch diameter hole saw to cut the spacers that separate the chair units.
- Make the spacers from two boards $\frac{3}{4}$ inch thick for the front spacers and $\frac{1}{2}$ inches thick for the rear ones.
- Hold the board on the machine table and cut through the stock, lowering the feed lever slowly.
- At the same time, the hole saw's pilot bit will bore a hole through the center of each spacer for the threaded rod.

3 – How to stack the units

- Once you have cut enough spacers, you can begin assembling the chair.
- Start by feeding the three threaded rods through the holes in one end unit and anchoring each with a nut and washer.
- Set the unit inside-face up on the shop floor and slip a spacer onto each rod, utilizing longer spacers at the back and shorter ones at the front.
- Afterward, fit a chair unit onto the rods and press it firmly on the spacers.
- Continue adding spacers and chair units until the last unit is in place, then install a washer and nut onto the top end of each rod.

4 – How to tighten the rods

- Close any gaps amongst the spacers and the chair units.
- Hand pressure should suffice at the back of the chair; utilize a wrench to tighten the nuts.
- At the front of the chair, install a bar clamp across the seat and tighten it as necessary to close any gaps; protect the stock with wood pads.
- Tighten the nuts at the front of the chair, and then give all the nuts a final tightening.
- Eliminate the bar clamps and utilize a hacksaw to cut the excess rod flush with the nuts.
- Cover the nuts with wood caps fashioned from short lengths of 1 inch dowel.

How to install the arms

1 – How to design the arms

- You can add arms to the curved chair, applying the same design and joinery techniques used to make the individual units.
- Start by preparing a template, holding a piece of hardboard opposed to one side of the chair and marking its outline with a pencil.
- Then design the arm so it will be both comfortable and visually pleasing; the armrest part should be 8 to 9 inches above the seat.
- Afterward, utilize a pencil and straightedge to outline the L-fashioned arm blank on the template, making it as wide as necessary to comprise the arm profile.
- Cut the template on a band saw and sand the edges smooth.

2 – How to outline the arm profile on the blanks

- Make each arm blank from two boards joined into an L-shape by half-laps.
- Set one of the blanks on the work exterior, position the template on it, and utilize a pencil to trace its outline on the stock.
- Mark the outer blank, then cut the arms to size on the band saw.
- Smooth the cut edges, sanding the stock to your cutting lines.

3 – How to round over the edges of the arms

- Round over the edges of the arms, except where they contact the chair.
- To mark out these areas, position each arm opposed to the chair and draw a pencil across it along the top of the seat and the front edge of the rear leg.
- Recall to mark out right and left-hand versions of the arm.
- Install a piloted round-over bit in a router and mount the tool in a table.
- To provide a bearing exterior for the arms, fashion a guard for the bit and a fence for the stock to ride opposed to the infeed side of

the table.

- Screw the guard and fence together and clamp them to the table.
- Press the work piece opposed to the pilot bearing as you feed each arm across the table, then turn over the stock and shape the other edge.
- When rounding over the inside faces of the arms start and stop the cuts at the marked contact lines.

4 – How to attach the arms to the chair

- Drill two clearance holes through each arm one at either end-and apply glue to the flat areas that will contact the chair.
- Clamp the arm in position on the chair and fasten it in place.

Chapter 8 How to make a lounge chair

Building lounge chair involves the better part of a day's work, but the completed merchandises will provide years of comfortable loafing and sun worshipping. The chair can be made with almost two dozen slats.

Those for the main body are simply screwed to a cleat fastened to the side rails; the backrest slats are joined to rails with half-laps. Butt hinges secure the backrest to the body.

The backrest can be adjusted from the horizontal position to nearly vertical, and the notched rack supporting the backrest allows it to be set at several positions in amongst. The lounge chair is lightweight and easy to move on wheels attached to the rear legs.

The wheels are held in place with axle caps. While this hardware is not as robust as cotter pins, it is easier to install and more than sturdy enough for the light-duty needs of the lounge chair.

Utilize a galvanized steel or aluminum rod for the axle. Since the slats are thin, try to select rather knot-free wood for these pieces.

How to develop the side rails

1 – How to round over the side rails

- Cut each of the side rails to size, clamp the stock face up to a work exterior, and saw the curves at the front end.
- Then install a piloted rounding-over bit in a router and make each pass by feeding the router along the edges of the rail, pressing the bit's pilot bearing opposed to the stock throughout the cut.
- Reposition the clamps as necessary.
- Turn the rail over and repeat on the other side

2 – How to drill the handle holes

- The handle at the front end of the chair is made from a length of 1 inch-diameter dowel.
- Bore the dowel holes in the side rails with an electric drill fitted

with a 1 inch Forstner bit.

- Clamp the stock inside, face upon a work exterior and mark out the holes, centering them amongst the edges about 1 ½ inches from the front end of the rail.
- Ensure the marks are in the same place on both rails.
- Holding the drill vertical, bore the hole, stopping when the body of the bit is completely recessed in the wood; this will yield a ½ inch deep hole.

3 – How to attach the cleats to the rails

- To position the cleats on the rails, mark a line along each rail's inside face 1 ½ inches from the bottom edge.
- Starting 2 inches from one end of the cleat, drill a clearance hole every 8 inches along its length.
- Then apply waterproof glue on the inside face of the cleat and position the stock on the side rail, aligning the back ends of the pieces.
- Anchor the cleat in place, holding the strip so its bottom edge is flush with the marked line on the rail as you drive each screw.
- Work from the back of the cleat to the front.

How to assemble the body

1 – How to prepare the slats

- Cut the slats for the body of the chair to size, and then drill two holes at each end of every piece.
- To keep the place of the holes uniform, do the job on your drill press aided by the modest jig.
- Start by securing a backup panel to the machine table and drilling the first of the holes-which are all $\frac{3}{4}$ inch from the end of the slats and $\frac{5}{8}$ inch from the nearest edge.
- For the jig, leave the slat in position and clamp two boards to the table as a fence and stop block.
- The fence should be flush opposed to the end of the slat and the stop block should be butted opposed to both the fence and the edge of the slat.
- Drill the second hole by turning the slat over and seating it in the jig.
- Repeat the procedure at the slat's other end and at both ends of the enduring slats.

2 – How to install the slats

- Once all the slats are ready, set the side rails on edge on a work exterior.
- Spread glue on the first slat and, starting at the front of the chair, set it on the cleats.
- The slat's front edge should be flush with the end of the cleats; its end should butt opposed to the rails.
- Confirm with a try square to ensure the slat is per-pendicular to the rails, and then screw the slat in place.
- To install the enduring slats, utalize a board the same thickness as the slats as a spacer.
- Confirm the assembly for square every four or five slats.

How to build the backrest

1 – How to prepare the backrest rails and slats

- The backrest slats are joined to the rails with half-laps.
- Outline the rabbets at the ends of the rails and the dadoes in amongst, making them as long as the rail width and as deep as one-half the stock thickness.
- Leave $\frac{3}{4}$ inch of space amongst the outlines.
- Install a dado head on your table saw, adjust it to maximum width, and set the cutting height.
- Attach an extension to your miter gauge.
- Saw the rabbets first, and then work from one end of the board to the other to cut the dadoes.
- For each channel, start by defining one shoulder, and then make a series of passes until you reach the other shoulder.
- Hold the rail flush opposed to the miter gauge extension throughout.
- Follow the same procedure to saw matching rabbets at both ends of the slats.

2 – How to attach the slats to the rails

- Drill two clearance holes at each end of every slat, and then spread glue in the rabbets and dadoes of the backrest rails.
- Set the rails face up on a work exterior and install the slats with screws, making sure their ends are flush with the outside edges of the rails.

3 – How to attach the backrest to the main body

- Set the backrest on the side rail cleats, leaving $\frac{3}{16}$ inch gap amongst the backrest and the last slat at the top end of the main body.
- Then position two butt hinges across the seam-one at each end-centering the hinge pin on the gap amongst the pieces.
- Mark the screw holes, drill a pilot hole at each mark, and screw

the hinges in place.

4 – How to install the racks

- Make the two racks from lengths of 1 ¼ inch square stock.
- Starting about 2 ½ inches from one end, cut a series of notches along the top edge of each rack on your band saw.
- The notches should be ¾ inch deep, angled at 45 degree, and spaced about 2 inches apart.
- Mount the racks by first fastening spacers the same width and thickness as the cleats to the side rails directly below the cleats.
- Then glue and screw the racks to the spacers, aligning the top edge of each strip with the bottom edge of the cleat.
- Lastly, attach the backrest support stops to the top edge of the racks, flush with the back ends.

5 – How to attach the backrest support

- Assemble the backrest support with half laps.
- Fasten the top end of the support to the chair with a piano hinge.
- Cut the hinge to the length of the support rails and screw it to the inside face of the top rail so the hinge pin extends just off the edge.
- Afterward, seat the bottom end of the support in one of the rack notches and tilt up both the support and backrest to the free piano hinge leaf is centered on the fifth slat from the bottom of the backrest tight.
- Mark the screw holes and drill a pilot hole in the slat at each mark.
- Turn the chair over and screw the hinge to the slat.

How to install the legs

1 – How to prepare the legs for the side rails

- The legs are attached to the side rails with rabbets cut on a table saw fitted with a miter gauge extension and a dado head adjusted to maximum width.
- Set the cutting height at one-half the leg thickness and angle the miter gauge to 45 degree.
- Position the rip fence for a 3 inch cutting width.
- Start by sawing the rabbet shoulder, holding the stock flush opposed to the fence and miter gauge extension.
- Then make a series of passes to eliminate the remaining waste.
- Once all four legs are rabbeted, cut the curve at their bottom ends on your band saw.
- Keep in mind that the rear legs are 1 ¾ inches shorter than the front ones to enable the wheels to contact the ground.

2 – How to prepare the rear legs for the wheel axles

- Mark an axle hole on one of the rear legs 1 7/8 inches below the rabbet shoulder.
- Then, install a ½ inch bit in your drill press and clamp a backup board to the machine table.
- Hold the leg very firmly as you drill the hole to ensure that the hole in the leg on the opposite side of the chair will be in exactly the same place, align the two legs face to face and slip a pencil through the hole to mark the position of the hole in the second leg.

3 – How to fasten the legs to the side rails

- Drill two clearance holes through the rabbet in each leg and spread glue on the joint.
- Screw the legs in place 18 inches from the ends of the rails.
- Drive the screws with the leg clamped in position so the rabbet cheek endures flush opposed to the face of the side rail and the shoulder butts opposed to the bottom edge of the rail.

- Repeat for the front legs.

4 – How to install the wheels

- Fit the axle rods through the holes in the legs, and then slip a washer and a wheel onto the axle alongside one leg.
- More than one washer may be necessary to enable the wheel to turn freely.
- Add another washer on the outside of the wheel, and then tap on an axle cap until it is snug.
- Install the wheel on the opposite side of the chair the same way, but prior to tapping on the axle cap, cut the rod so it extends $\frac{1}{2}$ inch beyond the wheel.
- Then install the cap.

Chapter 9 How to make a Porch Swing

Rocking motions seem intrinsically comforting to people of all ages. Pleasant and relaxing, a swing or a gliding settee provides an ideal accessory to a porch or garden.

The two ventures discussed in the following chapters also offer interesting mechanical challenges to a furniture maker. These pieces must be robust and lightweight. They must also stand up to a stress that furniture hardly ever has to endure continuous movement.

There are several ways to achieve a rocking motion. The modest solution is to suspend the seat with rope or chain. This requires a sturdy branch or structural member to support the swing.

The glider support uses a different system to impart a swinging motion. Four lengths of metal strap support the bench within a low frame. Other techniques utilize commercially obtainable roller bearings.

It is vital to buy hardware that is as corrosion-resistant as possible, especially for these pieces of furniture that are hard to cart indoors for the winter.

Stainless steel straps and screws, while more expensive than their regular steel counterparts, are robust and will not rust. Brass screws are not so robust, but offer a decorative option that is also corrosion resistant.

If you utilize brass, drive in a steel screw first to tap the hole, then eliminate it and install the brass screw taking care not to over tighten or you will risk breaking off the head.

The comfort of the swing, and the bench used with the glider depend upon the appropriate curvature of the seat and back supports. The seat should be angled fairly so the people utilizing it will stay firmly seated when it rocks back and forth.

A seat tilted toward the back also proves more comfortable for prolonged sitting. A curve in the seat back will support the lumbar region of the spine, but do not make these curves too pronounced, or the sitter will find it hard to get in and out of the swing.

The back seat rail is bevelled to a 15 to 25 degree angle, so as to provide a comfortable angle for the seat back. The back is screwed and glued onto the

rail, the same technique used to join most of the frame.

The arms, which provide supplementary support for the back, are the exclusion to the glue-and-screw technique. They are fastened together by cross dowels. These are robust joints, but must be cautiously installed to work appropriately.

The stiles of the seat back are located in front of the rails so the joint line is vertical, promoting good water drainage for a long-lived joint.

Requirements:

- *Back slats: Quantity: 13, Thickness: 1/2 inches, Width: 2 15/16 inches, Length: 24 1/4 inches*
- *Seat slats: Quantity: 6, Thickness: 3/4 inches, Width: 3 3/16 inches, Length: 55 1/2 inches*
- *Back rails: Quantity: 2, Thickness: 1 1/8 inches, Width: 4 3/4 inches, Length: 55 inches*
- *Back stiles: Quantity: 2, Thickness: 1 1/8 inches, Width: 4 3/4 inches, Length: 28 inches*
- *Front seat rail: Quantity: 1, Thickness: 2 inches, Width: 3 1/2 inches, Length: 60 inches*
- *Back seat rail: Quantity: 1, Thickness: 1 1/3 inches, Width: 2 inches, Length: 60 inches*
- *Rail cover: Quantity: 1, Thickness: 1/4 inches, Width: 4 3/4 inches, Length: 45 1/2 inches*
- *Seat supports: Quantity: 4, Thickness: 1 3/4 inches, Width: 3 1/2 inches, Length: 15 3/4 inches*
- *Arms: Quantity: 2, Thickness: 3/4 inches, Width: 5 3/4 inches, Length: 24 inches*
- *Arm posts: Quantity: 2, Thickness: 3/4 inches, Width: 2 7/8 inches, Length: 11 1/2 inches*

How to prepare the back rails

1 - Sawing dados in the lower back rail

- To prepare the rail for the slats, you will need to cut 2 inch-wide, ½ inch-deep dados in the stock.
- First, fit your table saw with a dado head and adjust it to maximum width, then attach an extension board to the miter gauge.
- Confirm the cutting height by making a test cut on scrap stock and adjust the blades until the cut is the same depth as the thickness of your slats.
- Mark the dado outlines on the leading edge of the work piece, beginning 8 ½ inches from each end and spacing the dados 1 1/8 inch apart.
- For each dado, saw the outside edges, then cut away the waste in the center.

2 - Attaching the rail cover

- Cut the rail cover to size, and then spread glue on the dadoed face of the rail and the rail cover.
- Position the two pieces together and tack the cover in place with brads, making sure not to nail any brads within 5 inches of either end of the rail.
- Afterward, clamp the assembly, making sure you apply pressure to every gluing exterior.

3 - Cutting corner half-laps

- The back assembly is composed of stiles joined to the two rails with half-laps.
- To cut the joint, utilize the same setup you made for sawing dados in the lower back rail.
- This time mark out the half laps at the end of each rail and stile.
- The joint should be as wide as the stile stock.
- Butt the stock opposed to the miter gauge extension, and line up

the blades to cut the shoulder of the half-lap first.

- Then saw away the enduring waste with multiple passes.
- Repeat the procedure to cut the joint at the other end of the stock and in the lasting rail and stiles.

4 - Decorating the top rail

- Trace the shape of the decorative top on the stock and cut it to shape with a band saw.
- Then attach it to the upper back rail with glue and clamp the two pieces together.

5 - Grooving the top rail

- You need to rout a groove in the upper back rail to hold the back slats. Fit a ½ inch three-wing slotting cutter in a router, and then mount the tool in a table.
- Mark the points on the face of the stock where the cut should start and end.
- Also mark the points on the fence where the bit starts and stops cutting.
- Adjust the height to center the groove in the edge of the rail.
- Turn on the router and pivot the rail into the cutter, aligning the front cutting line on the work piece with the bit cutting mark on the fence farthest from you.
- Push the rail along the fence until the back cutting line aligns with the bit cutting mark closest to you, then pivot the trailing edge of the work piece away from the cutter, steadying the board opposed to the table and fence by hooking your left hand around the front edge of the table.
- Utilize a chisel to square the ends of the groove, if necessary.

How to assemble the back

1 - Installing the slats

- Clamp the lower rail so it stands right-side up on your work exterior.
- Fit a slat into each notch and tap the slats until the ends are flush with the bottom of the rail.
- Drive a finishing nail into each slat through the back of the rail to secure the piece in place, and then fit the upper back rail onto the slats.

2 - Gluing up the back assembly

- Lay the partially assembled seat back on your work exterior.
- Apply adhesive to the corner lap joints of the rails and stiles and clamp the assembly together.
- Then glue spacers in the groove amongst the slats in the upper back rail.

How to assemble the seat

1 - Assembling the frame

- Cut a 15 to 20 degree bevel on the rear face of the back seat rail, utilizing a table saw with the blade tilted to the appropriate angle.
- Then prepare four seat supports.
- Cut the pieces on a band saw, utilizing the first support as a template for the others.
- Smooth the edges on a spindle sander.
- Glue and screw the frame together, locating the outside supports 2 inches from the ends of the rails.

2 - Attaching the eye bolts

- Drill a hole through the protruding end of each seat rail just large enough to accommodate a stainless steel eye bolt.
- Slip the eye bolt in place, add a washer and nut, and tighten the bolt firmly in place.
- Trim the excess bolt, if necessary.

3 - Attaching the back to the seat frame

- Clamp the seat frame bevelled edge up on a work exterior.
- Spread glue on the edge and on the front face of the lower rail of the seat back.
- Clamp the back to the seat frame, then drill pilot holes and screw the two assemblies together.

How to install the arms and slats

1 - Attaching the arm posts

- Position the arm post 2 inches from the end of the front seat rail flush with the bottom of the rail.
- Drill 4 pilot holes, then glue the arm post in place and secure it with screws.
- Repeat the procedure for the second arm post.

2 – How to attach the arm with cross dowels

- Cut out the arms on a band saw.
- There is both a right and left arm, so be sure not to mix them up.
- Round over the edges of the arms with a router fitted with a round-over bit.
- Then utilize a bevel gauge to transfer the angle of the chair back to the back edge of the arm and make the cut on your table saw.
- This will allow the arm, which is horizontal, to fit flush opposed to the chair back.
- Then drill a hole the same diameter as the cross-dowel both through the arm into the arm post.
- Ensure you drill straight.
- Afterward, bore a hole into the arm post for the cross-dowel connector about 2 inches from the top of the post, intercepting the bolt hole at 90 degree.
- Insert the connector in its hole, then slide the bolt into position and tighten it with a hex wrench.
- Install cross dowels in the same fashion to connect the back of the seat to the arm.
- Repeat the procedure to attach the second arm.

3 – How to add the seat slats

- Round over the front and back edges of the slats.
- Then install the front seat slat, notching it to fit around the arm posts.

- The front edge of the slat should be flush with the front of the arm post; the ends of the slats should venture beyond the edge of the end seat supports by $\frac{1}{2}$ inch.
- Mark the position of the supports and drill pilot holes, then screw the slat in place.
- To install the enduring slats, utilize spacers $\frac{1}{8}$ to $\frac{1}{4}$ inch thick to set the distance amongst the pieces.
- Tap the ends of the slats until they are all aligned.
- Then drill pilot holes and screw the slats in place.

4 – How to attach the chains

- Install a screw eye in each of the seat back stiles 2 inches above the arm.
- Then mark the point on each arm directly over the front eye bolt and drill a hole to accommodate a $1 \frac{3}{4}$ inch-diameter brass bushing.
- Insert the bushing and fasten it in place.
- Attach a length of chain with an opening link to each of the eye bolts in the seat rails.
- Thread the chain from the front eye bolts through the bushings; the chain from the rear eye bolts passes through the screw eyes in the back stiles.
- Join the chains on each side of the chair in pairs with opening chain links, giving you two points from which the chair can be hung.

Chapter 10 How to make a Glider Base

A versatile glider base can be adapted to fit different designs of benches. In this case, it has been constructed to support the bench. With modest changes, this design could simply add swinging motion to a chair, or a bench up to three persons wide.

The base consists of two side frames connected by two central beams that are separated by a spacer. The frames are made of rails and stiles joined with corner half-laps.

The beams can be shortened or lengthened as necessary, depending on the size of the bench or chair, but recall that the longer the bench, the more its weight, and Thus the greater the stress on the glider base.

The bench swings on 18 inch metal straps. They should be angled fairly inward so the top ends are farther apart than the lower ends. This will tend to slow the glider down as it approaches the ends of its swing. It also decreases mechanical stresses on the bench and glider frame.

Requirements:

- Side frame rails: Quantity: 4, Thickness: 1/3 inches, Width: 3 ½ inches, Length: 28 inches
- Side frame stiles: Quantity: 4, Thickness: 1/3 inches, Width: 3 ½ inches, Length: 20 inches
- Feet: Quantity: 2, Thickness: 1 3/4 inches, Width: 3 ½ inches, Length: 34 inches
- Foot pads: Quantity: 4, Thickness: 1 1/3 inches, Width: 3 ½ inches, Length: 5 ¾ inches
- Spacer blocks: Quantity: 2, Thickness: 1 1/4 inches, Width: 1 ¾ inches, Length: 3 ½ inches
- Center beams: Quantity: 2, Thickness: 1 ¾ inches, Width: 3 ½ inches, Length: 50 5/8 inches
- Support straps: Quantity: 4, Thickness: 1/8 inches, Width: 1 inches, Length: 18 inches

To do list:

1 – How to make the feet

- Round over the back edge of each foot pad on a disk sander.
- Glue and screw the pads in place, with the front edge flush with the front of the foot.
- Then round over the front edges of each pad and foot.

2 – How to assemble the sides

- Cut half lap joints in the side rails and stiles.
- Assemble each joint with four screws and glue, then center the feet on the bottom of each side and drill a pilot hole $5 \frac{3}{4}$ inches from each end into the lower side rails for a $3 \frac{1}{2}$ inch long, $\frac{1}{4}$ inch-diameter lag bolt.
- Add a washer, then insert the bolt in the hole and tighten it with a wrench.

3 - Attaching the center beams to the sides

- Glue and screw a spacer block to the center of the inside face of each side rail.
- Then glue and screw the center beams on either side of each spacer block.
- Then attach the beams to the other spacer block, confirming with a square on both lower side rails to ensure the assembly is perfectly square.

How to install the gliders

1 - Drilling the holes in the support straps

- Strike the strap with a center punch 1 inch from each end.
- This will dimple the exterior, providing a starting point for your drill.
- Afterward, fit a 3/8 inch bit into your drill press.
- Clamp a piece of scrap wood to the machine table as a backup board, then position the strap with the mark you just made centered under the bit.
- Place a second piece of wood on top of the strap to prevent the drill bit from lifting the strap as the bit is retracted from the hole.
- Bore the hole.
- Repeat at the other end and for the three other straps.

2 - Drilling holes for the bushings

- Mark out holes for 5/8 inch-diameter threaded bushings on the side rails and on the legs of the bench.
- This hardware will protect the wood from wear by the bolts that will secure the support straps to the frame and the piece of furniture.
- On the stand, locate each hole 1 5/8 inches from the top edge and 2 1/4 inches from the outside edge.
- On the bench legs, the holes should be centered in the middle of the legs, 1 inch from the bottom.
- If you are adapting the stand to fit another piece of furniture, ensure that the ends of the metal straps are mounted a couple of inches closer together on the furniture than on the glider frame.
- This will improve the gliding motion.
- Drill holes for the bushings with a spade bit.
- Bore three-quarters of the way through each hole, and then complete the hole from the other side.
- Ensure the holes are square with the face of the frame.

3 - Installing the bushings

- Add threaded bushings by twisting them finger tight, and then finish tightening them with a screwdriver or a coin.
- If the bushing begins to enter the hole askew, eliminate it and enlarge the hole fairly with a rail.
- When it is installed, the bushing should rest fairly proud of the exterior of the wood.

4 – How to bolt on the support straps

- Slide a ¼ inch-diameter bolt through each of the support straps, slip on a washer, and fit the bolts through each of the bushings in the upper frame rail.
- Secure the bolts in place with a lock washer and two nuts, utilizing a second wrench to hold one of the nuts in place while you tighten the other one.
- Afterward, position the bench amongst the sides of the frame, and repeat the bolting procedure.
- It will be easier to do this job with a helper to hold the bench in place while you slide the bolts through the bushings in the legs.
- Tighten the nuts.

5 - Adding the rub rail

- The rub rail is a 28 inch-long piece of ½ inch aluminium C stock.
- Drill a hole at each end, and then place the rail amongst the support straps and the glider frame, with the lower edge of the rail flush with the upper edge of the bottom side rail.
- Screw the rub rail in place, and then attach the second rail on the opposite side of the slider frame.

Chapter 11 How to make a garden Bench

While a lone chair may be suited to solitary reflection, benches call out for company. More than anything, a bench is an invitation, beckoning visitors to sit and chat or simply appreciate the surrounding views.

In the following chapters I will explain how to build three different styles of benches. The garden bench will suit more formal tastes. Its solid, upright backrest puts it in character in a well-ordered garden.

But in the right place, the bench could also serve as an interesting counterpoint to a more informal layout. In either case, try to situate it in front of tall flowers or shrubs, which will serve as a backdrop to frame the piece.

The park bench is a versatile piece. The curved lines of its armrests and legs give it a more casual look than the garden bench. A modest and eye-catching bench when used by itself, it can be transformed into a glider when combined with the base.

The park bench is rather modest to make, assembled with butt joints that are reinforced by screws. The joinery is more than sufficiently robust, and eliminates the risk that the connecting parts of the bench will trap water that could rot the wood.

The tree bench must harmonize with its setting both in its color and size. Ideally, it should appear to be almost an organic outgrowth of its environment.

Made by encircling a tree trunk with six modular seats that are attached end to end, the bench must be planned and intended with a particular tree in mind. The internal diameter of the bench should exceed that of the trunk by about 6 inches.

The garden bench is a sophisticated piece of furniture. Building it demands as much precision and attention to detail as any indoor venture. It also incorporates features that give it the required strength and resilience to face the elements.

The bottom ends of the arm support and back slats, for instance, are housed in dadoes that extend right through the rails, allowing any moisture to drain out.

To make the bench, start by assembling the legs and rails, and then add the arms and their slats, forming the two end units. Afterward, install the longer pieces that bridge the ends, such as the front seat rail and back rails.

Lastly, finish the seat and back. To ensure that all exteriors of the bench are uniformly smooth when the time comes to apply a finish, sand the pieces prior to fastening them in place.

How to assemble the end units

1 - Making the rear legs

- To outline the curved rear legs on the stock, start by making apply wood or hardboard template; the legs are vertical from their bottom ends to the seat and then curve backward at about 10 degree, an angle that most users will find comfortable.
- Once the template is ready, trace its outline on the leg stock with a pencil.
- Utilizing a 2-by-6 will enable you to utilize the same blank for both legs.
- Cut the legs on your band saw.

2 - Gutting the half-lap joints

- All of the dados and rabbets for the half-laps used to assemble the end units can be cut on the table saw, except for those on the back edges of the rear legs for the back seat rail.
- These are cut on a band saw as the cuts are located on the inside of the leg curves, and the stock cannot rest flat on a table saw table at these points.
- Start by making all the table saw cuts, and then outline the enduring dado on each rear leg.
- Feeding the stock into the blade with both hands, cut the sides of the dado with two cross-grain cuts, then make a series of curved and straight cuts to eliminate the lasting waste.

3 - Attaching the end and stretcher rails to the legs

- Set front and rear legs from the same side of the bench outside face up on a work exterior and apply waterproof glue in the dados.
- Tap the end and stretcher rails in position, confirm the unit for square and drill pilot holes in the rails, two at each end of the end rail and one into the stretcher rail.
- Screw the pieces together.

4 - Installing the arms

- Screw the arm support slats to the end rails, making certain that the supports' bottom ends are flush with the bottom edges of the rails.
- Then, holding one leg assembly upright, set the arm in position, centering it on the supports and butting the back end opposed to the rear leg.
- Outline the supports on the underside of the arm and cut a $\frac{1}{4}$ inch-deep mortise into the arm within each outline.
- Also bore two clearance holes through the arm in line with the front leg and through the rear leg into the end of the arm.
- Afterward, spread some glue in the arm mortises and at the points where the arm contacts the legs, fit the arm in position again, and screw it to the legs.

How to attach the seat rails and middle stretcher

1 – How to install the seat rails

- Start by attaching the front seat rail to the front legs, utilizing a mallet and wood block to tap the half-laps together, and glue and screws to fix the pieces.
- For the back rail, set the assembly upright on a work exterior, position the board opposed to the rear legs, and mark the position of the notch that must be cut in the end to enable the outside face of the rail to sit flush with the back edges of the legs.
- Cut the notch, then glue and screw the rail to the legs.

2 – How to attach the middle stretcher

- Cut a rabbet at each end of the stretcher to mate with the dados in the end stretchers.
- Drill two clearance holes through the stretcher at each end of the board, then spread some glue in the rabbets, set the piece in position and screw it down.

3 – How to round over the front seat rail

- To make the bench more comfortable, round over the top edge of the front seat rail.
- Install a piloted rounding-over bit in a router and set the depth of cut to reach your final depth in two passes.
- Make the first pass along the inside face of the rail.
- Butting the router base plate opposed to one front leg and holding the tool level on the rail, feed the bit into the stock and along the rail; ensure the bit's pilot bearing is pressed opposed to the stock throughout.
- Stop the cut when the router contacts the opposite front leg, then repeat the pass along the rail's front face.
- Increase the cutting depth and make two more passes.

How to install the seats

1 - Attaching the cleats and seat supports

- Secure the cleats to the seat rails with glue and screws spaced at 8 inch intervals; position the cleats so that the top edges of the seat supports and seat rails lie flush.
- With the cleats in position, set the bench on its back and attach the end seat supports to the cleats, driving the screws from underneath; the supports should be flush opposed to the legs and end rails.
- Afterward, fasten the middle seat supports to the cleats, spacing them equally and holding each piece in position as you drive the screws.

2 - Installing the seat slats

- Round over the top edges of the seat slats and test fit them in the bench so that there is $\frac{1}{4}$ inch gap amongst them; trim the slats edges if necessary.
- Mark the places of the seat supports on each slat and drill two clearance holes through the slats at each mark.
- Starting at the front seat rail, screw the slats to the supports, utilizing $\frac{1}{4}$ inch spacers to maintain the gap amongst the pieces.

How to assemble the back

1 - Shaping the upper back rail

- Cut the upper back rail to size, and then saw the rabbets at its ends.
- Outline the curve along the rail's top edge utilizing a template.
- Align the template with the top corner of the rail at one end and mark its outline with a pencil.
- Repeat at the other end, and then cut away the waste on your band saw.

2 - Preparing the rail for the back slats

- Cut the groove for the slats along the rail on your table saw equipped with a dado head.
- Adjust the width of the blades to the slat thickness $\frac{3}{8}$ inch, and the cutting height to 1 inch.
- Center the rail over the blades and butt the rip fence opposed to the stock.
- To help keep the rail pressed opposed to the fence, clamp a feather board to the saw table, braced by a support board installed at a 90 degree angle; round over the top edge of the feather board to facilitate lowering the work piece onto the blades.
- To help you determine the position of the dado head when it is hidden by the rail while the cut, mark two lines on the fence at the point where the blades start and stop cutting.
- Holding the rail opposed to the fence just above the blades and aligning the front end of the piece with the cutting mark on the fence, slowly lower it onto the head.
- Once the rail is sitting squarely on the table, feed it forward while pressing it opposed to the fence.
- Stop the cut once the back end of the rail reaches the back cutting mark.

3 - Fastening the lower back rail to the rear legs

- Prepare the lower back rail and then install the back slats in the

rail, proceeding as you would for a porch swing.

- Spread some glue on the contacting exteriors of the lower rail and rear legs, fit the assemblies together and drive two screws into each end of the rail.

4 - Attaching the upper back rail

- Positioning the upper rail over the slats, start at one end to push the rail down, snapping the slats into the groove as you go.
- Once the pieces are all in place, glue and screw the half-laps joining the rail and rear legs.
- To complete the bench, glue wood filler strips in the upper rail groove amongst the slats.
- This will keep the slats from shifting.

Chapter 12 How to make a park bench

The park bench can serve as a stationary bench, or as a glider. The height of the bench without the glider may be a bit low for some users, but adding 3 inches to the leg lengths provided in the requirements will yield a standard-height bench.

Utilizing mainly modest butt joints, the park bench is rather straightforward to construct. While not as robust as the half-lap, the butt joint is quick and easy to assemble and it does an even better job of shedding water and moisture.

Reinforcing the joinery with waterproof glue and screws makes it sufficiently robust. Another concession to straightforwardness is the usage of same-size stock for back and seat slats. This enables you rip all the slats with the same setting on your table saw, speeding building and reducing errors.

Requirements:

- *Front legs: Quantity: 2, Thickness: 1 1/4 inches, Width: 4 inches, Length: 20 3/4 inches*
- *Rear legs: Quantity: 3, Thickness: 1 1/4 inches, Width: 5 inches, Length: 33 3/8 inches*
- *Seat rails: Quantity: 3, Thickness: 1 1/4 inches, Width: 4 3/4 inches, Length: 21 inches*
- *Arms: Quantity: 2, Thickness: 3/4 inches, Width: 6 inches, Length: 23 inches*
- *Front rail: Quantity: 1, Thickness: 3/4 inches, Width: 4 3/4 inches, Length: 46 inches*
- *Rear rails: Quantity: 2, Thickness: 3/4 inches, Width: 2 3/4 inches, Length: 46 inches*
- *Upper back rail: Quantity: 1, Thickness: 3/4 inches, Width: 2 inches, Length: 49 1/4 inches*
- *Seat slats: Quantity: 6, Thickness: 3/4 inches, Width: 3 inches, Length: 47 inches*
- *Back slats: Quantity: 7, Thickness: 3/4 inches, Width: 3 inches, Length: 47 inches*

How to make the end units

1 – How to shape the legs

- Start building the bench by assembling the end units, which consist of the seat and seat rails.
- Referring to the requirements, make templates for the front and rear legs.
- Then trace the designs onto your leg stock and cut out the legs on the band saw.
- Smooth the exteriors of each leg with a sanding block, securing the stock to a work exterior and sanding with the grain.
- Rearrange the leg in the clamps as necessary.

2 – How to attach the seat rails to the legs

- Cut the seat rails to size, then fasten one to each leg.
- Mark layout lines on the legs to position the rail appropriately.
- The rail should be inset from the outside edges of the legs by $\frac{3}{4}$ inch to allow the front and rear rails to be set flush with the leg's edges.
- The bottom edge of the seat rail should be $5\frac{3}{4}$ inches from the bottom of the rear leg and 6 inches from the bottom of the front leg.
- Spread some glue on the contacting exteriors of the pieces, align the rail with your layout lines, and utilize a try square as you fasten the rails to the legs to ensure that the bottom edge of the rails endures perpendicular to the outside edge of each leg.

How to assemble the seats

1 – How to install the front and rear rails

- Cut the front and rear rails to size and drill clearance holes at the ends of each piece.
- Utilizing glue and screws fasten the rear rail in place; drive one screw at each end to start, confirm for square, and then install the lasting fasteners.
- Install the front rail the same way, and then attach the third seat rail to the front and rear rails, cantering it amongst the end units.

2 – How to install the seat slats

- Cut the entire seat and back slats to size and round over their edges.
- Drill two clearance holes through each piece at every seat rail place.
- Afterward, notch the first seat slat at the front of the bench to fit around the front legs.
- To ensure the slat sits flush opposed to the curved front edge of the legs, hold it in position on the rails, outline the leg profile at each end with a pencil and trim to the line with a chisel.
- Screw the slats in place, separating them with $\frac{1}{4}$ inch spacers.

How to install the arm

1 – How to shape the arm

- Outline the appropriate cutting pattern on one arm blank, and then cut the notch at the back end of the blank that will enable the arm to fit around the rear leg.
- To ensure the inside exteriors of the arm and rear leg will align, hold the blank in position and mark a line along the top face of the blank that parallels the leg's inside face.
- Cut the arm to shape on your band saw, and then utilize a router to round over all its edges, except for those that define the notch.
- Utilize the first arm to outline the opposite one.

2 - Installing the arms

- Position the arm on the bench so that the inside edge is flush with the rear leg and overhangs the inside face of the front leg by 17 inches.
- Mark place lines on the underside of the arm and drill clearance holes through it.
- Then apply glue to the contacting exteriors of the arm and legs and fasten each arm in place.

How to assemble the back

1 - Rabbeting the back slats

- Cut the rabbets at the ends of the back slats on your table saw.
- Install a dado head and adjust its width to fairly more than $\frac{1}{2}$ inch.
- Then attach an auxiliary fence, position the fence for a $\frac{1}{2}$ inch cutting width, and raise the blades into the wooden fence to notch it, making sure that the dado head is clear of the metal one.
- Adjust the cutting height to one-half the slat thickness and screw an extension board to the miter gauge.
- Feed the slats rounded-over side up, holding the stock flush opposed to the fence and miter gauge extension while you make the cut.

2 - Attaching back slats and rail

- Utilizing glue and two screws at each end, fasten the back slats to the rear legs; cut $\frac{1}{16}$ inch spacers to maintain the appropriate gap amongst the bottommost back slat and the seat, and $\frac{1}{4}$ inch spacers for the lasting rows.
- Prior to applying glue to the fourth slat from the bottom, notch it at each end to fit around the arms.
- Once all the back slats are installed, utilize two screws to fasten the bottom end of the back support piece to the seat slat at the back of the bench.
- Complete the bench by installing the upper back rail.
- Apply glue to the contacting exteriors of the rail and legs, and then screw the support in position.

Chapter 13 How to make a Tree Bench

If you install a tree bench it can become an integral part of its environment, appearing as natural, necessary, and stable as the tree it encircles. Indeed, this bench is by definition a custom made venture.

You cannot complete the requirements until you measure the circumference of the tree around which the bench will fit. Refer to the requirements to help you size the variable parts of your venture.

While final assembly of the bench is done on site, you will avoid frustration if you first test-assemble the six identical seating units in the shop. Once you are satisfied with the fit, disassemble the bench only partially to move it.

Eliminate the cap rail, seat, slats, back slats and apron from two opposite sections, leaving two pairs of seat sections intact. When you reach your tree, position the two intact sections around the trunk, then reattach the eliminated sections.

Requirements:

- Legs: Quantity: 6, Thickness: 1 3/8 inches, Width: 3 5/8 inches, Length: 40 inches
- Braces: Quantity: 6, Thickness: 1 3/8 inches, Width: 3 inches, Length: 16 3/4 inches
- Seat supports: Quantity: 12, Thickness: 1 3/8 inches, Width: 3 5/8 inches, Length: 17 3/4 inches
- Back cleats: Quantity: 12, Thickness: 1 1/2 inches, Width: 1 1/2 inches, Length: 25 inches
- Cap rails: Quantity: 6, Thickness: 1 5/8 inches, Width: 3 1/2 inches
- Aprons: Quantity: 4, Thickness: 1 3/8 inches, Width: 3 1/2 inches
- Back slats: Quantity: 18, Thickness: 1 1/4 inches, Width: 4 inches
- Seat slats: Quantity: 18, Thickness: 1 1/4 inches, Width: 4 inches
- Carriage bolts: Quantity: 12, Width: 5/16 diameter, Length: 5 inches

The size of some tree bench parts-the cap rails, aprons, and slats depend on the circumference of the tree. Since the mitered cap rails hug the tree closest, their length along the inside edges is critical.

Ideally, there should be a 1 1/2 inch gap amongst the cap rails and the tree at the midpoint of each rail. Start by measuring the tree's circumference by wrapping a measuring tape around the trunk at the cap rail height.

Cut the length of the other variable pieces, the aprons and slats to fit. If the

tree circumference is less than 50 inches, utilize 12 $\frac{3}{4}$ inch long cap rails. If it exceeds 112 inches, you will need to build an octagonal bench, or find a smaller tree.

How to make the support assemblies

1 – How to assemble the legs, braces and seat supports

- Start building the bench by making the six support assemblies; each one comprises a leg and brace and two seat supports.
- Miter the bottom end of the brace at a 72 degree angle, then trim the bottom corner with a cut at a 90 degree angle to the miter cut; this second cut should intersect the end of the brace 3 $\frac{1}{4}$ inches from the top edge.
- Make a 45 degree miter cut at the other end of the brace so that the board measures 16 $\frac{3}{4}$ inches along its bottom edge.
- Holding the brace at a 105 degree angle to the leg 4 inches from the leg's bottom end, outline the bottom end of the brace on the face of the leg.
- Then cut out the marked notch on your band saw.
- Afterward, utilize glue and a screw to fasten the brace to the leg, driving the fastener through the brace's bottom edge.
- Now cut the seat supports to length, beveling the front end at 30 inches.
- The back end of each support should be flush with the leg's back edge and the support's top edge should be flush with the top end of the brace.
- Clamp the supports in position on the leg and brace, and mark a hole at each end of both supports for a 5/16 inch-diameter carriage bolt.
- Drill the holes and install the bolts, washers and nuts, tightening with a wrench.

2 – How to prepare the back cleats

- Make the 12 back cleats from lengths of 1 $\frac{1}{2}$ by 1 $\frac{1}{2}$ inch stock.

- Rip both edges of each piece at a 30 degree angle so the narrow face of the cleat is $\frac{3}{4}$ inch wide.
- Cut the bottom end of the cleat so it will sit flat on the seat support with the wide face flush opposed to the leg.
- To trim the top end of the cleat, hold it in position opposed to the seat support and leg, mark your cutting line along the leg's top end, and make the cut on the band saw.

3 - Attaching the cleats to the legs.

- To offset the cleats from the front edge of the legs by the required $1 \frac{3}{4}$ inches, make a $\frac{5}{16}$ inch-thick spacer that you can utilize to space the cleat from the leg's back edge.
- Drill three clearance holes through the cleat and, utilizing glue to bond the cleat to the leg, fasten the cleat in place.
- Hold the spacer opposed to the cleat and flush with the leg's back edge as you drive the screws.

How to join the support assemblies

1 – How to install the cap rails

- Cut the cap rails to length, mitering the ends at 60 degree and beveling the front edge at 70 degree.
- Drill two clearance holes through the rails at each end.
- Then prop up two support assemblies and mark a line along the top end of each leg that divides its thickness in half.
- Align the ends of the cap rail with the marked lines and fasten the piece to the legs.
- Now, add on another cap rail and support assembly, continuing until all six of each are installed.

2 - Spacing the support assemblies

- Once all the cap rails are in place, set the legs upright on the shop floor and confirm whether the support assemblies are equally spaced.
- Making sure the ends of all the legs are flat on the floor, measure from the inside face of one right hand side seat support to the inside face of the adjoining piece.
- Repeat with the lasting supports and gently nudge the legs to one side or the other, if necessary, until all your measurements are equal.
- This may take some trial and error.

3 – How to size the aprons

- You will need to mark one apron in position to determine the final length of the pieces.
- Start by cutting the aprons about 36 inches longer than the cap rails.
- Afterward, mark lines along the top ends of two adjoining braces that divide their thickness in half, and clamp a wood strip as a straightedge along each marked line.
- To mark the apron, work with a helper to hold the board in

position at each end; making sure the apron is flush opposed to the seat supports and butted opposed to the underside of the straightedges, run a pencil along the wood strip at each end of the apron.

- Trim the apron, and then utilize the piece to mark the remaining ones.

4 - Attaching the aprons

- Drill a pair of clearance holes at each end of the aprons.
- Utilizing straightedges to centre the ends of the pieces across the braces screw the aprons in place.
- You may need a helper to hold up the opposite end of each apron as you drive the first pair of screws.

How to install the seats

1 - Marking the first seat slat

- Start sizing the seat slats at the back of the bench.
- To determine the exact angle at which you will need to miter the ends of the slats, hold the first blank in position on the seat supports and opposed to the legs and utilize a sliding bevel to measure the angle formed by the slat and one leg.
- Adjust the miter gauge on your table saw to this angle.
- To locate your cutting lines on the board, mark lines along the front edges of the legs that divide their thickness in half.
- Then, with the slat blank in position, draw the cutting marks $\frac{1}{8}$ inch inside those on the legs.
- This will leave the required $\frac{1}{4}$ gap amongst slats.
- Trim the slat to length and utilize it to size the remaining ones.
- Then fasten the slats to the seat supports with two screws at each end, leaving a $\frac{1}{4}$ gap amongst the pieces.

2 - Attaching the remaining seat slats

- The second and third rows of the seat slats are installed in much the same way as the first.
- To mark each slat, set it on the seat supports and butt it edge to edge opposed to the first slat, placing a $\frac{3}{4}$ inch-thick spacer stick amongst the slats.
- Then utilize a pencil and a rule to mark lines across the face of the slat that align with the ends of the first slat.
- Miter the slat and fasten it to the seat supports, maintaining the $\frac{1}{4}$ inch gap amongst the ends and a $\frac{3}{4}$ inch space amongst edges.

3 – How to trim the back slats to length

- The ends of the back slats must be cut at a compound angle both mitered and bevelled, so they sit flush opposed to the legs of the tree bench.
- To mark the slats, set a $6 \frac{3}{4}$ inch wide spacer on edge on the first

seat slat and place the back slat blank on the spacer.

- Holding the slat flat opposed to two adjoining legs, run a pencil along the inside face of the each leg to mark cutting lines on the face of the slat.
- To cut the compound angle on your table saw, angle the blade to 60 degree and adjust the miter gauge to the angle marked on the slat.
- Utilize the slat as a guide to trimming the others in the bottom tier.

4 - Installing the back slats

- Drill two clearance holes at each end of every back slat.
- Utilizing the spacer to separate the slat from the seat slat below and a clamp to hold the slat level, fasten each piece to the back cleats.
- Install the second and third tiers of back slats the same way, but utilize a $\frac{3}{4}$ inch thick spacer to separate the board edges.
- Apply your finish prior to setting up the bench in its chosen place outdoors and so avoid splattering the tree with paint, stain, or varnish.
- Prior to transporting the bench, eliminate the cap rail, apron and slats from two opposite sides of the assembly.
- This will leave two pairs of frame sections that, together with the eliminated pieces, are easy to move.
- Once the two frame sections are distance around the tree, you can reinstall the detached boards.

How to setup the tree bench

Once all the pieces of your tree bench have been fastened in place, work with a helper to lift it and position the assembly around the tree. The gap amongst the trunk and cap rails should be equal around the tree's circumference.

As the terrain is unlikely to be as level as your shop floor, one or more of the legs may not be in contact with the ground. Rotating the bench in one direction or the other may solve the issue. If not, trim a leg that is resting on higher ground, or prop up a leg that is not touching the ground.

Chapter 14 How to make an 8 sided planter

The arbor, planter, and serving trolley, which I will discuss in the following chapters complement other furniture designs features in this book. The arbor creates a base for climbing plants and a decorative focal point for outdoor creation or relaxation.

Planters can be used to establish flowers or other plantings in any part of a garden. And with its capacity to transport both victuals and kitchen items like plates, dishes, and cutlery the serving trolleys are welcome convenience for backyard entertaining.

The planter is built from white cedar formed into staves. A $\frac{3}{4}$ inch piece of marine-grade plywood forms the bottom, and the staves are joined with spline-and-groove joints.

A lip around the top edge protects the ends of the staves and adds a decorative element. For an eight-sided planter, the edges of the staves must be beveled at $22\frac{1}{2}$ degree.

The table-saw jig will enable you to cut the bevels and taper the staves at the same time so they are wider at the top than at the bottom. The serving trolley is built around a frame joined with half laps and reinforced by glue and screws.

The slats on the bottom rest on cleats running along the inside faces of the lower side rails. The top consists of four rails that slip over the frame assembly, and are screwed to the top of the frame.

The trolley rolls on two wheels of the type intended for gas barbecues. Indeed, the trolley could be used to replace the frequently flimsy metal bases provided with numerous barbecues.

The arbor is built from rough-sawn cedar left without a finish, the wood will turn an eye-catching silver hue as it weathers. Meanwhile, the natural decay-resistance of cedar will protect the piece from the elements.

One practical advantage of leaving the wood bare is that the arbor will never require refinishing a plus once climbing plants weaving themselves into the trellis and around the posts. The sides of the arbor are built with tusk tenons and joined with half-laps, and the trellises are held in place by cleats.

While the top of the piece is simply nailed to the sides, the venture does not skimp on traditional joinery techniques the arbor relies on no fewer than 148 half lap joints.

While white cedar was chosen for these ventures, other decay-resistant, eye-catching woods such as redwood and red cedar will work equally well.

How to prepare the staves

1 – How to bevel one edge of the staves

- With the shop-built tapering jig, you can bevel the edges of the staves and taper them in a single setup.
- For the jig, make the base from a piece of 12 inch-wide plywood, and the guide bar and stop block from solid stock.
- Start by angling the blade to $22\frac{1}{2}$, then utilize the bar clamps to secure the stave blank to the base so the edge extends off the base by $1\frac{1}{4}$ inch at the leading end and $\frac{1}{4}$ inch at the trailing ends.
- Butt the guide bar and stop block opposed to the stock, clamp them in place and fix the pieces to the base.
- Screw toggle clamps to the guide bar and utilize them to secure the blank to the jig to protect the stock with wood pads.
- Eliminate the bar clamps.
- Afterward, butt the edges of the jig base opposed to the blade and the rip fence opposed to the opposite edge of the base.
- Start feeding the jig and work piece with both hands, but move your right hand safely away about halfway through the cut.
- Finish the pass with your left hand, keeping the jig flush opposed to the fence throughout.
- Bevel one edge of every stave the same way.

2 - Cutting the opposite edges

- To avoid having to adjust the blade angle when you bevel the opposite edge of each stave, clamp the blank to the base as in step 1, but with its narrow end at the leading end of the base.
- Ensure the narrow end of the blank extends off the base by $1\frac{1}{4}$ inch and the wide end by $\frac{1}{4}$ inch.
- Position the guide bar and stop block opposed to the work piece, and screw the pieces to the base from underneath.
- Eliminate the bar clamps and bevel each stave.

How to assemble the planter

1 – How to prepare the staves for the splines

- Fit your table saw with a dado head, adjust its width to the spline thickness $\frac{1}{4}$ inches, and set the cutting height to $\frac{3}{8}$ inch.
- Center the edge of a stave over the blades, then butt the rip fence opposed to one face of the stock and clamp a guide board to the saw table opposed to the opposite face.
- Feed the stave into the head, keeping the outside face flush opposed to the fence.
- To determine the width of the plywood splines, secure two staves upright in hand screws, butt the pieces edge to edge, and measure the combined depth of their grooves.
- Cut the splines the same length as the staves, ripping them as wide as your measurement, less $\frac{1}{8}$ inch.

2 - Trimming the ends of the staves

- Once all the spline grooves have been cut, dry fit the staves together with the splines.
- Utilize surgical tubing to hold the assembly together.
- To level the staves at the top and bottom, both ends of each piece will have to be beveled.
- To determine the bevel angle, hold a board as a straightedge across the top of the assembly and utilize a sliding bevel to measure the angle amongst the outside face of a stave and the straightedge.
- Tilt your table saw blade to the measured angle and clamp an extension board to the miter gauge.
- Align the cutting mark at one end of the stave with the blade, then butt a stop block opposed to the end of the stock and clamp it to the extension.
- Angle the miter gauge so the ends will be cut straight across.
- Then, holding the work piece flush opposed to the extension and stop block, bevel the end of each stave.
- Utilize the same setup to bevel the opposite ends of the staves.

3 - Preparing the staves for the bottom

- Cut dados across the inside faces of the staves for the bottom with a similar setup you used for crosscutting the staves.

- Adjust the width of the dado head to $\frac{3}{4}$ inch and tilt the blades to the same angle you measured in step 2.
- Set the cutting height to $\frac{3}{8}$ inch.
- Clamp the stop block to the miter gauge extension to locate the dado $\frac{3}{4}$ inch from the bottom of the staves.
- Angle the miter gauge as you did in the previous step to compensate for the tapered sides of the staves.
- Hold the work piece flush opposed to the extension and the stop block as you feed it across the saw table.

4 – How to cut the bottom of the planter

- Dry fit the staves and splines together.
- Center the assembly on a piece of $\frac{3}{4}$ inch marine-grade plywood and outline the outside of the planter on the work piece.
- Then mark a second outline within the first, offset from it by $\frac{1}{2}$ inch to compensate for the dados in the staves.
- Utilize the second outline as your cutting pattern as you saw out the bottom on your band saw.
- Once the bottom is cut out, drill a few drainage holes through it.

5 - Assembling the planter

- Test fit all the pieces together, making sure the splines fit snugly in their grooves and the bottom fits into its dados.
- Utilize a chisel to fine-tune any ill-fitting joints.
- Spread glue in the spline grooves, and then fit the staves around the bottom, slipping the splines in place as you go.
- Push the splines down until their ends are flush with the bottom piece.
- Once all the pieces are in place, secure the assembly with two lengths of surgical tubing, bicycle inner tube, or band clamps wrapped around the staves-one near the top and one near the bottom.
- Also install two bar clamps at each end of the planter on opposite sides of the staves.
- Trim the splines flush with the top end of the staves utilizing a

flush-cutting saw.

6 – How to install the lip

- Trim the lip pieces to length by mitering each end at $22\frac{1}{2}$ degree.
- Apply glue to the contacting exteriors of the staves and lip pieces, and position each piece so its ends align with the seams amongst the staves.
- Utilize two nails to fix each lip piece to its stave.

Chapter 15 How to make a Serving Trolley

The serving trolley rolls on wheels intended as a replacement for gas barbecues. With its convenient handle, the trolley is easy to move around, and its stout legs and rails, joined with half lap joinery, make the sturdy and durable piece of woodworking venture.

Requirements:

- Top end rails: Quantity: 2, Thickness: 1 1/4 inches, Width: 2 1/2 inches, Length: 21 1/8 inches
- Handle rails: Quantity: 2, Thickness: 1 1/4 inches, Width: 2 1/2 inches, Length: 47 inches
- Upper slats: Quantity: 18, Thickness: 3/4 inches, Width: 1 3/4 inches, Length: 20 1/8 inches
- Upper side rails: Quantity: 2, Thickness: 1 1/4 inches, Width: 4 inches, Length: 32 inches
- Upper end rails: Quantity: 2, Thickness: 1 1/4 inches, Width: 4 inches, Length: 20 inches
- Front legs: Quantity: 2, Thickness: 1 1/2 inches, Width: 2 1/2 inches, Length: 27 inches
- Rear legs: Quantity: 2, Thickness: 1 1/2 inches, Width: 2 1/2 inches, Length: 30 inches
- Lower end rails: Quantity: 2, Thickness: 1 1/4 inches, Width: 2 1/4 inches, Length: 20 inches
- Lower side rails: Quantity: 2, Thickness: 1 1/4 inches, Width: 2 1/4 inches, Length: 32 inches
- Lower slats: Quantity: 15, Thickness: 3/4 inches, Width: 1 3/4 inches, Length: 17 1/2 inches
- Handle: Quantity: 1, Width: 1 inches, Length: 21 1/2 inches
- Cleats: Quantity: 2, Thickness: 1 1/4 inches, Width: 1 1/4 inches, Length: 30 5/8 inches

How to make the frame

1 – How to prepare the stock

- Consisting of the side and end rails, and the legs, the frame of the serving trolley is assembled with half lap joinery.
- On your table saw, install a dado head and adjust it to maximum width.
- Refer to the requirements for the size of the rabbets and dados required.
- At the bottom end of the rear legs, For instance, start by cutting a rabbet along the outside face to accept the lower side rail.
- The length of the rabbet should equal the width of the side rail and its depth should be one-half the stock thickness.
- Afterward, cut a rabbet along the outside edge of the leg to accommodate the lower end rail.
- Position the rip fence so you can feed the stock along the fence as you define the rabbet shoulder, then make a series of passes to eliminate the remaining waste.
- Guide the work piece with the miter gauge for each of these passes.

2 – How to fasten the side rails and legs together

- Once all the joinery cuts are made, spread glue on the contacting exteriors of the legs and side rails, and fit the rails and one pair of front and rear legs together.
- Utilize two screws to reinforce each joint, driving the fasteners through the rails and into the legs.
- To confirm whether the assembly is square, measure diagonals amongst opposite corners immediately after tightening the screws.
- The two outcomes should be the same.
- If not, install a bar clamp across the longer diagonal.
- Tighten the clamp a little at a time, measuring as you go until the two diagonals are equal.

3 – How to install the end rails

- Once both sides of the frame are assembled, add the four end rails.
- Utilize glue and screws to fasten the upper end rails to the legs, then set the assembly upside down and fix the lower end rails in position.

4 - Installing the lower slats

- Utilizing glue and screws, attach a cleat along the inside face of each lower side rail so the top edges of the cleats are $\frac{5}{8}$ inch below the top edges of the rails; apply only a few drops of adhesive along the length of the cleat, rather than covering its entire exterior to avoid trapping water amongst the rails and cleats.
- Start installing the slats at one end rail.
- Notch the ends of the first and last slats to accommodate the legs, and fix each piece in place with two nails at each end.
- Utilize $\frac{1}{4}$ inch spacers to separate the slats.

How to attach the top

1 – Preparing the handle rails

- Start by preparing the handle rails for the top end rails and the handle. For the end rails, cut a ½ inch-deep, 1 ¼ inch wide dado across the inside face of each handle rail.
- For the handle, drill a 1 inch diameter hole as deep as one-half the stock thickness.
- Afterward, outline the curve at the front end of the rail and cut it on your band saw.
- Utilize the rail to outline the curve on the second piece and repeat the cut.
- Smooth the cut exterior with sandpaper or a spindle sander, then round over the outside edges with a router.

2 – How to assemble the top frame

- Utilizing glue and screws, fasten the top end rails to one of the handle rails.
- Glue the handle into its hole, then fit the second handle rail onto the assembly, fixing it in place with adhesive and screws.

3 – How to attach the support blocks

- Cut four 1 inch-square blocks and drill a 1/8 inch-diameter hole through each one.
- Glued and screwed to the handle rails, the blocks will support the slats at the front and back ends of the top.
- Clamp the top assembly on edge to a work exterior and attach a block to each corner formed by the handle rails and top end rails; position the blocks 7/8 inch below the top edge of the rails

4 – How to attach the top to the upper rails

- Lower the top over the upper rails: it should fit snugly around the outside of the frame.

- Holding the top so that the top edges of the support blocks and upper rails are flush, fasten the rails together.
- Glue and fasten the top slats in place.
- Utilize the support blocks and the top of the frame to support the slats in place of the long cleats used in the bottom of the frame. Install the upper slats as you did the lower ones, nailing them to the upper rails and support blocks.

5 – How to install the wheels

- Set the trolley upside down on a work exterior and drill a 5/8 inch-diameter hole through each lower rail 3 inches from its end.
- Ensure the holes are aligned.
- Slide a 1/2 inch-diameter axle rod through the holes and slip a washer on each end of the rod.
- Fit a wheel onto each end of the axle, and then lock it in place with a second washer and a pressure nut.
- Tap the nut in place with a hammer, while holding a block of wood opposed to the opposite end of the axle.

Chapter 16 How to make a Garden Arbor

1 – How to rough the side rails

- Start building the arbor by cutting the tusk tenons that join the side rails to the post.
- To cut the tenons at the ends of the rails on your table saw, install a dado head and adjust it to its maximum width, and attach an extension board to the miter gauge.
- Set the cutting height at ½ inch and position the rip fence for a 12 inch wide cut.
- Feed the rail face down with one end riding along the fence to define the tenon shoulder.
- Make a series of passes to complete the tenon cheek, then turn the rail over and repeat the procedure on the other side.
- Cut tenons at the other end of the rail and at both ends of the enduring rails.
- Hold the edge of the rail flush opposed to the miter gauge extension for every pass.

2 – How to rough out the mortises in the posts

- You can cut the post mortises by hand, or utilize a mortiser or a drill press, fitted with either a mortising attachment or a 1 inch diameter spade bit.
- The mortises should start 18 inches from the bottom and 24 inches from the top of the posts.
- Utilize the completed tenons to lay out the length and width of the mortises, making sure the outlines are centered on the inside faces of the posts.
- Then clamp a backup panel to your drill press table and set the post on the panel, centering the outline under the bit.
- Drill a hole through the post at each end of the outline, and then bore a series of overlapping holes to complete the mortise.

3 – How to clean up the mortises

- Square the walls of the mortises utilizing a chisel as wide as the mortises.
- Holding the chisel vertically, bevel facing the waste, align the tip with one of your cutting lines and tap the tool with a wooden mallet.
- Continue around the perimeter of the mortise until all the waste is cleared away.
- Test fit each tenon in its mortise and widen or lengthen the cavity as required.

4 – How to assemble the posts and rails

- Fit the posts and rails together and mark a line along the top of each cheek where the tenon emerges from the mortise.
- Disassemble the joint and drill a 1 inch diameter hole through the tenon centered on the line.
- Cut a ½ by 1 inch hardwood piece into the bullet shape and make the length of the tenon wedge about equal to the post thickness.
- Slide the tenon into the mortise and strike the wedge firmly with a hammer until the joint is tight.

How to install the trellis

1 - Installing the cleats

- Cut the cleats that frame the inside edges of the posts and side rails, mitering both ends of each piece at 45 degree.
- Start with the cleats along the rails, nailing the pieces in place, and then install the one along the posts.
- For each cleat, drive the first nail about 2 inches from one end, continuing at about 8 inch intervals.
- Utilize a tape measure periodically to confirm that the cleats are offset by about 1/8 inch from the outside edges of the posts and rails.

2 – How to prepare the lattice strips

- The dados for the half laps joining the lattice strips together can be cut one after another on the table saw utilizing a dado head and a modest jig made from an extension board clamped to the miter gauge.
- Feed the extension into the blades to cut a dado, and then slide the extension along the miter gauge so the space amongst the dado and the blades equals 4 inches.
- Screw the extension to the gauge and cut a second dado.
- Then, insert a tight-fitting wooden key in the first dado so it ventures at least 2 inches from the extension.
- For each lattice strip, butt the edge of the board opposed to the key and hold an edge flush opposed to the extension.
- Feed the strip into the blades to cut a first dado, and then fit the notch you just cut over the key and make a second cut.
- Continue cutting dados in this manner until you reach the opposite end of the strip.
- Hook your thumbs around the extension to steady the strip while each pass.

3 - Cutting the lattice strips to length

- Once all the joinery cuts have been in the lattice strips, utilize the same setup to cut the pieces to length.
- Replace the dado head with a combination blade.
- For each strip, slip the last dado you cut over the key and feed the piece into the blade.

4 – How to assemble and install the lattice

- Lay out the horizontal lattice strips on a work exterior, spread some glue into all the dados and fit the vertical strips in position.
- Utilize a wooden mallet to close the joints snugly, and then reinforce every second joint with a nail.
- To install the lattice, hold the panel opposed to the inside face of the cleats and fasten the strips to the cleats, driving a screw into each corner and into the center of each side.

5 – How to attach the cap rails

- Cut a 1 inch deep rabbet at each end of the cap rails; the rabbets should be as long as the post width.
- Set a side assembly on a work exterior, spread glue on the contacting exteriors and fit the cap rail in position.
- Reinforce each joint with screws.

How to build the top

1 – How to outline the half laps on the top rails

- The top rails comprising the top of the arbor are joined with half lap joints.
- To mark out the dadoes in all the pieces in a single setup and ensure that they align, clamp the five short top rails and then the four long top rails together face to face.
- Ensure the ends of the pieces in each set align.
- Starting 14 inches from one end of the boards, begin marking the dado shoulders.
- To extend the lines accurately across the rails, utilize a carpenter's square, butting one arm opposed to the outside edge of the stock.
- Each dado should be 2 inches wide.
- Mark the dado depth 2 inches on each rail.

2 – How to saw the dado shoulders

- As the top rails are unwieldy to cut on the table saw, you should make the dadoes by hand.
- Clamp the work piece bottom face up to a work exterior and utilize a crosscut saw to cut along the shoulder lines.
- Stop each kerf at the depth line.

3 – How to chisel out the waste

- Once all the dado shoulders have been cut, turn the work piece on one side and utilize a chisel as wide as the dadoes to eliminate the waste.
- Starting just below the bottom edge of the stock, hold the chisel vertically, with the bevel facing the bottom edge, and tap the tool with a mallet to sever a piece of waste wood.
- Continue in this fashion until you make a final cut with the chisel tip aligned with the depth line.

4 – How to shape the ends of the top rails

- Draw the decorative curve at the ends of the top rails on the piece of $\frac{1}{4}$ inch plywood and cut out the profile on your band saw.
- Utilizing the plywood piece as a template, transfer the curve onto each rail.
- Clamp the rail to a work exterior with the end to be cut extending off the table, and cut the curve with a saber saw.
- Once all the rails have been fashioned, sand the cut ends smooth and assemble the pieces with glue and screws as you did the lattice.

How to install the arbor

1 – How to bury the anchors

- The posts of the arbor can be set in concrete or more simply metal anchors that are driven into the ground.
- Place the arbor where it will go and mark the place of the posts.
- Fit a length of post stock into each anchor and utilize a sledgehammer to drive the stock and anchor into the ground.
- Continue until the top end of each anchor is near the ground.
- Ensure the tops of the four anchors are all level.
- Eliminate the post stock from the anchors and insert the posts.

2 – How to attach the front and back rails

- Cut a 1 inch-deep and 3 inch long rabbet at each end of the front and back rails.
- Then fit the rails in place and secure them with two screws at each end.

3 – How to install the top

- To complete building the arbor, work with a helper to lift the top into position.
- If you are utilizing stepladders, ensure they are placed securely on solid ground.
- Nail the top rails of the arbor to the cap rails.

Chapter 17 How to make a Bookcase

Whether it is a modest plywood structure or a custom-made wall unit crafted from fine hardwood, a bookcase serves two purposes at once. It is an efficient storage system, accommodating books and other items that accumulate in most homes, and a fine piece of furniture in its own.

A basic bookcase can be adapted to store just about anything. With the addition of some specialized hardware, a modest bookcase can be transformed into a home entertainment center to house a television, stereo components and computer gear.

This utilitarian versatility makes the bookcase one of the woodshop's most popular ventures. While the appearance of a bookcase may vary from one unit to another, the principles of its design endure continuous.

Every bookcase must strike a balance amongst its size and the size and weight of the items it is intended to hold. Shelves, For instance, must be long enough to do their job, but not so long that they will sag in use.

Shelves can be fixed in place or adjustable. Each has its own advantages. Adjustable shelving permits a more flexible organization of a bookcase's interior space, but fixed shelves lend a bookcase structural rigidity.

You have to contemplate a choice of building supplies, joinery techniques, and ornamentation when building a bookcase. The chapter that follows particulars the building of a basic unit.

You may wish to add a face frame to strengthen the piece and frequently its lines. Molded bases and feet can allow a bookcase to harmonize with other pieces of furniture that will surround it.

For a modest technique of stringing a series of bookcases together into a wall unit. By putting your imagination, skill, and patience to work, you will be able to reap the rewards of building a fine piece of useful furniture.

In spite of refinements such as crown and base molding, a face frame and turned feet, the bookcase at right is basically a carcass with shelves. Most of the other particulars of the bookcase, from the shelves to the feet, are discussed in this chapter.

Design a bookcase to suit the items it will store. Standard bookshelves, For

instance, are at least 8 inches deep and 9 inches apart; allow an supplementary 3 or 4 inches of depth and height for oversize books.

Record albums need 13 inches in both depth and height. Televisions, and stereo equipment may require up to 24 inches of depth. After you have settled on dimensions, decide which type of shelving best suits your needs.

The bookcase I will discuss features three adjustable, or floating, shelves and one fixed shelf. While the fixed shelf cannot be moved once installed, it helps to strengthen the piece and is less likely to sag than adjustable shelves.

The load the shelves will have to bear should be contemplated when choosing supplies. The denser the lumber, the sturdier the shelf. Also Recall that a shelf weakens as it increases in length.

Shelves that are long are not likely to break, but they will almost always sag. If you are planning a bookcase wider than 36 inches, contemplate installing cleats under the middle of the shelves at the back or a vertical partition amongst them.

Books are not the only items commonly stored in a bookcase. With the commercial accessories, you can simply organize record albums, compact discs, audio tapes, and videocassettes. If you intend your bookcase to house a stereo system or television can tame the tangle of wires and connectors that accompany them.

Specialty items like runners let you slide shelves in and out of the carcass, providing easy access to the contents, while swivel attachments can be installed on a sliding shelf or the bookcase top for a television set. You can even illuminate the inside of your bookcase with a cabinet light or hide and protect the contents behind tinted glass or acrylic doors held closed by magnetic latches.

How to make adjustable shelving

- While adjustable shelves do not contribute to the strength of a bookcase, they do give it greater flexibility allowing you to adapt to changing needs and organize space most efficiently.
- It is unwise to make a bookcase without providing at least one fixed shelf for structural rigidity.
- Adjustable shelves are commonly held in place with wood, plastic,

- or metal shelf supports that fit in holes drilled in the carcass sides.
- The trick is to make certain that the rows of holes are perfectly aligned. Utilize a commercial shelf-drilling jig or a shop-made jig to bore the holes.
- Other options embrace adjustable shelf standards, which are mounted in grooves in the side panels, or shop-made corner strips.
- These are dadoed and attached to the interior curves of the bookcase to hold up the shelving.

1 – How to drill holes for the sleeves

- This mounting system requires two parallel rows of holes to be drilled in the side panels of the bookcase.
- The commercial jig allows you to bore holes at 1 inch intervals and ensures that corresponding holes will be perfectly aligned.
- Set the side panels inside-face-up on a work exterior and clamp the jig to the edges of one panel; the holes can be any distance from the panel edges, but about 2 inches in would be best for the panels.
- Fit your electric drill with a bit the same diameter as the sleeves and install a stop collar to mark the drilling depth equal to the sleeve length.
- Starting at either end of one of the jig's rails, place the appropriate bushing in the first hole of the bushing carrier.
- The bushing keeps the bit perfectly square to the work piece.
- Holding the drill and carrier, bore the hole.
- Bore a series of equally spaced holes along both rails.
- Eliminate the jig and repeat for the other side panel, cautiously positioning the jig so that the holes will be aligned with those in the first panel.

2 - Mounting the sleeves and supports

- To install threaded sleeves without damaging them, utilize a sleeve-setting punch.
- Place a sleeve on the end of the punch and push it firmly into one of the holes in a side panel.

- Insert a sleeve into each hole you drilled.
- Once you have installed all the sleeves, screw shelf supports into the sleeves a teach shelf place.

How to make a hidden shelf support

1 - Making and installing the shelf supports

- Utilize a jig to bore holes for the shelf supports.
- Make two supports per shelf.
- Each one is a thin wood strip about 1 inch longer than the gap amongst the rows of holes; make the strip wide enough to hold a dowel at each end.
- 3/8 inch dowels are large enough for regular loads.
- To help you position the dowels on the supports, insert a dowel center into each of two parallel holes and press the strip opposed to the points.
- Utilize the indentations from the centers as starting points for drilling the holes.
- Make the holes in the shelf supports the same depth as the holes in the side panels.
- Glue dowels into the shelf supports and, once the adhesive has dried, install them on the side panels at the height that you want the shelf to rest.

2 - Preparing and installing the shelves

- To conceal the shelf supports, cut blind rabbets in each shelf.
- Mark out the rabbets by positioning the shelf on the supports and outlining their places on the underside of the shelf.
- Cut the rabbets utilizing a router fitted with a rabbeting bit and square the ends with a chisel and a wooden mallet.
- The rabbets should be as deep as the thickness of the shelf supports.
- Once all the rabbets have been cut, test fit the shelf in the bookcase.
- Utilize a chisel to adjust the rabbets, if necessary, to ensure a perfect fit that completely hides the support.

3 – Installing the standards

- Metal standards and clips are among the modest accessories to install for mounting adjustable shelves in a bookcase.
- Two slotted standards, or tracks, are fastened to the inside faces of the side panels and shelf-support clips are inserted in the slots at the desired height.
- Rather than notching the shelves to accommodate the standards, recess the tracks in grooves cut in the side panels.
- Install a dado blade on your table saw and cut two parallel grooves in each panel.
- The grooves should be as wide and as deep as the standards; for the width of panel shown, position the grooves about 2 inches in from each edge.
- With the panels inside-face-up on a work exterior, set the standards in the grooves and fix them in place, driving screws through the predrilled holes in the tracks.
- Attach clips to the standards at each shelf place.

How to make corner strips

1 - Making the corner strips

- Dadoed corner strips installed in each inside corner allow bookcase shelves to be adjusted.
- You can make four strips from a single 4 inch-wide board that is long enough to extend from top to bottom of the interior.
- Install a dado head on your table saw and set the width equal to the thickness of the shelf supports you plan to use.
- Determine the desired spacing of the notches and cut two dados that distance apart in a miter gauge extension board.
- Line up the left-hand dado with the blade and screw the extension to your gauge.
- One dado should be offset to the right; cut a 2 inch piece of shelf support stock and press it into that dado, where it will serve as an indexing key.
- Butt one end of the work piece opposed to the key and cut your first dado.
- Cut the second and subsequent dados by moving the piece to the right and fitting the last dado over the key.
- When the dados are all cut, rip the board into four 1 inch corner strips.

2 - Installing the corner strips and shelf supports

- Position each strip in a corner of the bookcase, making sure that the dados face the interior, and screw the strips to the sides at top and bottom.
- Place an extra fastener in the middle on a tall bookcase.
- For the shelf supports, measure the distance amongst the front and back of the bookcase and cut the supports to fit.
- Ensure that the supports are wide enough to hold the shelves appropriately; test fit them to ensure that they fit snugly in the dados.

3 – How to prepare the shelves

- All four curves of each shelf must be notched to fit around the corner strips.
- After measuring and marking each shelf, secure it in a vise and cut out the curves with a backsaw.

How to make fixed shelves

Fixed shelves bolster the structural integrity of a bookcase, but since they cannot be moved once they are installed, you need to give cautious thought to their place.

You can mount fixed shelves quite simply by screwing them to cleats that are fastened to the back and side panels. Your bookcase will be robust and more eye-catching, nevertheless, if the shelves are attached to the side panels utilizing one of the joinery techniques shown below.

If you do not intend to add a face frame to your bookcase, recall that some of these joints will conceal the cut made in the side panel for the shelf.

1 – How to prepare the side panels

- The half-dovetail dados in the side panels are routed in two steps.
- First with a straight bit, and then with a dovetail bit.
- Install a straight bit of the desired diameter in your router.
- Clamp the side panels edge-to-edge and inside-face-up to a work exterior; ensure their ends are aligned.
- Clamp aboard opposed to the stock at the end of the cutting line to prevent tear out.
- Also clamp an edge guide across the panels, offset to appropriately locate the edge of the router base plate and the bit.
- Starting at one edge of the panels, feed the router across the stock, pressing the base plate opposed to the edge guide throughout the cut.
- Complete the dado by making the second cut with a dovetail bit, shifting the edge guide away from the first cut by one-half the dovetail bit diameter.

2 - Preparing the shelf

- To create mating half-dovetail tongues on the ends of the shelves, leave the dovetail bit in the router and mount the tool in a table.
- Position the fence for a shallow cut.
- Feed the shelf on end into the bit, keeping it flush opposed to the fence with one hand while pushing it forward with the other hand.

- Test fit the cut end in a half dovetail dado.
- Adjust the fit, if necessary, by moving the fence 1/16 inch away from the bit and making another pass.
- Repeat the cut at the other end of the shelf.

Edge treatments are strips of solid wood, veneer, or commercial banding applied to the visible edges of plywood shelves; they conceal the panels' plies, creating the illusion that the shelving is made of solid wood.

Commercial edge banding is obtainable by the roll in a wide diversity of wood versions, colors, and widths. To install, simply cut off the length you need, set it in place, and heat it with a household iron to melt the adhesive that bonds it to the edge of the shelf.

While a little more painstaking to apply, shop-made wood strips offer several advantages over store-bought banding. They are frequently less costly, and you can finish your shelf edges with any obtainable wood species, cut to whatever thickness you desire. A diversity of solid wood edge treatments is discussed below.

Procedure:

- A piece of hardwood can be glued to the edge of a shelf to strengthen it.
- To rout the rabbet in the edge piece, install a $\frac{3}{4}$ inch straight bit in your router and mount the tool in a table.
- Set the fence for a width of cut equal to the thickness of the shelf.
- To secure the work piece throughout the cut, screw a feather board to a shim and clamp the assembly to the table.
- The shim will raise the feather board to apply pressure to the middle of the work piece.
- Also install feather boards to the fence on both sides of the bit.
- For the sake of clarity, the feather board on the out feed side of the fence has been eliminated in the illustration.
- Do not attempt to rout the rabbet in one pass.
- Instead, make a series of passes, increasing the depth of cut each time.
- Repeat until the shelf fits flush in the rabbet.

- You can round or shape the edge piece to your liking.

As they completely cover the edges of side panels, face frames are ideally suited for plywood bookcase building. Made from a contrasting wood, they can also provide a decorative detail.

Cutting and assembling a face frame demands precision; the joints must be tight and the frame square if it is to fit appropriately and provide strength. Utilize the assembled carcass as a reference to measure the rails and stiles. Face frames are either glued in place or attached with biscuit joints as shown below.

How to install a face frame

1 – How to cut slots in the carcass and face frame

- Measure your carcass and cut the two rails and stiles of the face frame to length; also cut median rails to cover any fixed shelves.
- The frame should rest flush with the outside of the carcass.
- Join the rails and stiles with dowels, biscuits, or mortise-and-tenon joints, then glue up the face frame assembly, ensuring that it is square.
- Once the adhesive is dry, sand it and place it on top of the bookcase.
- Mark the places of the biscuit joints on both the carcass and the face frame-typically every 4 to 6 inches.
- Set the plate joiner for the biscuit you are utilizing and cut the slots in the carcass, aligning the guideline on the face plate with each pencil mark.
- Then cut mating slots in the frame.

2 – How to install the face frame

- Apply glue to the slots in the carcass and face frame and along the mating exteriors.
- Insert the biscuits in the carcass slots, and then set the face frame in place.
- Work rapidly since the glue will cause the biscuits to expand almost immediately.

3 - Clamping the assembly

- Clamp the face frame to the carcass about every 12 inches.
- To apply pressure to the center of the median rail, utilize a piece of stock clamped to the carcass at either end with a shim in the middle.
- Base molding is frequently added to a bookcase to "anchor" the piece and complement any crown molding installed at the top.

There are two basic ways to build a base.

- The first is to make rabbeted mitered frame of molded pieces from stock standing on edge.
- This frame wraps around the base of the bookcase like a skirt and hides the joinery at the bottom of the carcass.
- The second technique involves building a mitered frame of horizontal molded stock; this provides a flat exterior for attaching turned feet.
- Both techniques allow for wood expansion and can also be adapted to fit modular bookcases or bookcases joined together.

How to install a rabbeted base molding

1 - Assembling the frame

- The frame is made from three pieces of molded stock, a back, and four corner braces.
- A rabbet is cut along the inside edge of the molded pieces, forming a lip that the bookcase will sit on.
- To make the base molding, first prepare three pieces of solid stock and rout a decorative molding in the edge of each.
- Then install a straight bit and cut a rabbet in the opposite face of each piece.
- Cut the molding to length with miters at both front curves, then cut a piece of stock for the back and join it to the sides with biscuits.
- Glue the front to the sides and screw corner braces in place to secure the joint.

2 – How to install the base molding

- Once you have completed assembling the frame, attach the unit to the bottom of the bookcase.
- To reinforce the joint, screw two angle brackets midway along the inside frame of the base molding.
- Spread glue on the rabbet on the front piece of the frame and on the first inch of the side pieces.
- This will cause any wood movement to take place toward the back of the carcass, preventing the miter joints at the front from breaking.
- Then set the frame in place on the bookcase, and screw the brackets so the bottom of the carcass.

If your bookshelf features no base molding and a fixed shelf is located near the bottom of the piece in place of a carcass bottom, you can install a bottom brace to hide the space below the shelf.

Simply cut the brace to size and glue or nail it in place from the ends and the top of the bottom shelf. You can also cut a decorative pattern in the brace.

A base molding glued or screwed to the front and sides from inside the carcase is another option. You might also select to attach ogee bracketed feet.

How to install the base with feet

1 - Turning the feet

- Cut blanks for the feet from the appropriate size stock.
- To turn each blank, determine its center, mount the block on a faceplate, and attach the faceplate to the lathe.
- Position the tool rest in line with the center of the blank and as close to the stock as possible without touching it, then utilize a round-end scraper to shape the foot.
- Always work on the "down" side of the spinning block to prevent kickback.
- Periodically confirm the profile of the foot with a pair of outside calipers.
- Once you are satisfied with its profile, sand the foot on the lathe with progressively finer sandpaper.

2 - Installing the feet

- Once you have turned all the feet, screw them to the bottom of the base molding.
- Unlike the vertical base molding, the base illustrated at left is horizontal, with a wide rabbet routed in the face of each piece that accepts the bottom of the bookcase; a molding is cut on the frame's outer edge.
- After assembling the base, drill a countersunk hole three-quarters of the way through the center of each foot, then bore a pilot hole the rest of the way through the wood.
- Screw the feet to the base.

If you are building more than one bookcase or a modular wall unit, contemplate attaching adjacent bookcases together for stability. A quick and efficient way to do the job is to utilize threaded connectors to join adjacent sides.

With the two bookcases side by side and appropriately aligned with each other, bore a hole through the two side panels.

Install a threaded connector; for stability, utilize four to six connectors along the length of the side panels. If your bookcases have face frames, you can install intermediate stiles to hide the gap amongst the two bookcases.

Chapter 18 How to make a Blanket Chest

The chest is one of the earliest versions of furniture, with along utilitarian tradition. While the middle Ages, chests served as the primary receptacles of household goods and valuables.

They were also called upon to perform double duty as a seating place, at a time when chairs were a luxury for most people. While early chest designs were primitive, medieval artisans frequently adorned them with carved arches and elaborate chivalric and battle scenes.

While the Renaissance and Baroque periods, the piece began to assume some of the elements that are still used today, including frame-and-panel joinery, molded tops and bases, and patterned bracket feet.

Over the years, eye-catching hardware was added, such as brass locks, handles, and escutcheons. In Colonial America, the chest was typically placed at the foot of a bed to store blankets, quilts, and linens-hence the name blanket chest.

Today, the piece is used to store everything from toys and clothing to books. Numerous chests are built with drawers for supplementary storage. Blanket chests are all rather similar, beginning with a rectangular carcass and a hinged top.

Dimensions vary but as a general guideline contemplate a length of 40 to 45 inches, a width of 18 to 20 inches, and a height of about 25 inches. The carcass is made from panels of edge glued boards and assembled with dovetail or frame-and-panel joinery.

The top features routed wood strips that are attached with sliding dovetail joints; or a molding can be cut into its edge. To prevent the top from warping, and as a decorative touch, wood battens can be fastened for stiffening.

The top can be attached with a piano hinge or butt hinges. You might select instead to install ogee bracket feet; these make a fitting base for bookcases and armoires as well. These items provide the final decorative touch and should be chosen cautiously to complement the particular design of your venture.

How to attach the top with a piano hinge

- The hinge should be equal to or fairly shorter than the length of the chest.
- Clamp the top to a work exterior utilizing wood pads to protect the stock.
- Hold the hinge in position, aligning the center of the pin with the back edge of the top, and trace its outline.
- Afterward, install a straight bit in a router and set the cutting depth to the thickness of the hinge leaf.
- Take care adjusting the depth; if the rabbet is too deep it will cause the hinge to bind when the lid is closed.
- Align the bit over the inside edge of the outline, and then fasten an edge guide butted opposed to the router base plate.
- Rout the inside edge of the rabbet, keeping the base plate pressed opposed to the edge guide.
- Make repeat cuts, adjusting the edge guide each time, until the rabbet is completed.
- Then, set the hinge in the rabbet and mark the place of the screw holes.
- If you are adding molding or battens, do so now.
- Then bore pilot holes at the marks, put the hinge back in position, and drive the screws.
- Set the top on the chest, with the free hinge leaf flat on the top edge of the blanket chest's back panel.
- Mark the place for the screws, bore pilot holes, and drive in the screws.

1 – How to trace the hinge outlines

- Instead of a piano hinge, you can utilize two or three butt hinges to attach the top to the blanket chest.
- The hinges are mortised into both the top and back panel of the chest.
- To begin, clamp the top good-side down on a work exterior and place the first hinge in position a few inches in from one end, positioning the pin just off the back edge of the top.
- Utilize a pencil to trace the outline of the hinge.
- Mark the other hinges on the top in the same manner, positioning

one near the other end and one in the center if necessary.

2 – How to chisel out the waste

- Utilize a chisel to score the hinge outline and cut it to the thickness of the hinge.
- Then, holding the chisel bevel up, pare the waste from the mortise.
- Repeat the procedure to clear out the enduring mortises.
- Be cautious to cut the mortises no deeper than the thickness of the hinge leaves to prevent binding.

3 – How to install the hinges

- Set the hinges in their mortises in the top, drill pilot holes, and screw them in place.
- Afterward, set the top on the chest, mark the place for the hinge mortises on the top edge of the back panel, then chisel them out following the procedure described in step 2.
- Now lay the chest on its back on a work exterior and set the top good-face down behind it.
- Place a wood spacer fairly denser than the top under the back of the blanket chest to line-up the free hinge leaves with their mortises.
- Bore pilot holes and screw the hinges in place.

A router is an ideal tool to cut mortises for your blanket chest's butt hinges, but do not try to do the job freehand. A jig will guarantee fast, accurate outcomes. You will need to equip your router with a straight bit and a template guide to make the cuts.

Make the template from a piece of $\frac{3}{4}$ inch plywood wide enough to support the router. Outline the hinge leaf on the template, being sure to compensate for the template guide and the thickness of the fence, which is also made from $\frac{3}{4}$ inch plywood.

Cut out the template, and then attach the fence with countersunk screws. To utilize the jig, secure the top of the chest edge-up in a vise. Mark the hinge outline on the work piece and clamp the template in position, aligning the cut

out with the outline on the edge and butting the fence opposed to the inner face of the top.

Make the cut, moving the router in small clockwise circles until the bottom of the recess is smooth, then square the curves with a chisel. When you are utilizing the jig to cut mortises in the top edge of the blanket chest, be sure to secure the carcass to prevent it from moving.

How to add molding to the top

1 – How to make the molding

- Install a molding bit in a router and mount the tool in a table.
- Rout the molding from stock denser than the top so that when the lid is shut the molding will overhang the side and front panels fairly.
- The stock should also be wider and longer than you need so that you can rip and crosscut the molding to size later.
- Align the fence with the bearing and feed the board into the bit to carve the design in one half of an edge.
- Mount a feather board on either side of the bit to secure the piece while the cut.
- Flip the piece over and rout the other half, creating a mirror cut of the first.
- Then rip and crosscut the molding to the size you need.

2 - Installing the molding

- You can secure the molding to the edge with sliding dovetails or glue alone.
- In this case, the side moldings are attached with stopped sliding dovetail so allow for cross-grain wood movement; the front molding, which will shrink and swell parallel to the top panel, is attached with glue.
- Make stopped dovetails on the ends of the top; cut stopped dovetail mortises in the side moldings.
- After you have made the dovetail joints, miter the ends of the molding at 45 degree.
- Then place the top good-face up on wood shims.
- Spread a thin layer of glue on the last two inches of the sliding dovetail and the dovetail slot, and then slide the molding into position.
- Afterward, lay some paper towel on the top to prevent scratches and install bar clamps with protective wood pads to secure the molding in place.

How to route molding in the top

1 – How to rout the edge

- Instead of attaching separate strips of molding, you can rout a decorative shape in the top itself.
- Secure the top good-face up on a work exterior with its edge venturing off the exterior.
- Install a piloted rounding over bit or another molding bit in your router, and then set the cutting height to mold the top part of the edge.
- Turn on the tool and guide the bit into the stock, moving the tool opposed to the direction of bit rotation and keeping the pilot bearing butted opposed to the stock.
- Once the top half of the edge is molded, flip the work piece over and rout the bottom half if called for by your design.

2 – How to add battens

- When molding is attached with sliding dovetails, it serves to stiffen the top, eliminating the need for battens; molding that is simply routed in the edge of the top does not offer this advantage.
- In this case, to prevent warping from changing humidity levels, fasten two or three battens across the underside of the top.
- Cut the strips of wood from the same stock as the top, making them about 1 ½ inches wide and 3 inches shorter than the width of the top.
- For visual appeal, round one end of each batten on the band saw.
- Afterward, set the top good-face down on a work exterior and hold the first batten in place about 5 inches from one end of the top.
- Drive three screws to fasten it in place.
- To allow the batten to expand and contract, enlarge the counter bored holes at the ends of the wood strips into ovals; the center screw is the only one that should be driven in tight.
- Repeat the procedure to mount the other battens.

How to make a bracket feet

1 – How to mark the pin board

- The feet of the blanket chest are made from two identical boards cut with a decorative scroll pattern and joined with half blind dovetail joints.
- Make the joinery cuts first, then saw out the patterns and assemble the pieces
- To begin, cut blanks to the size of the feet, and then mark the half blind dovetails.
- Indicate the outside face of each board with an X.
- Then adjust a cutting gauge to the thickness of the stock and scribe a line across the inside face of the pin board to mark the shoulder line.
- Afterward, secure the board end up in a vise, set the cutting gauge to about one-third the stock's thickness, and mark a line across the end closer to its outside face.
- Utilize a dovetail square to mark the pins on the end of the board.
- For the size of board, a half-pin at each edge and two equally spaced pins in amongst will make a robust and eye-catching joint.
- Indicate the waste sections with X-s, then utilize a combination square to extend the lines down the inside face to the shoulder line.
- Repeat the marks on all the pin boards.

2 – How to cut the pins

- Secure a pin board in a vise with its outside face toward you, and then cut down along the edges of the pins with a dovetail saw, working from one edge of the board to the other.
- For each cut, align the saw blade just to the waste side of the cutting lines.
- Utilize smooth, even strokes, continuing the cuts to the shoulder line.
- Afterward, clamp the board outside face down on a work exterior and utilize a chisel and mallet to pare away the waste wood.
- Score a line about 1/8 inches deep along the shoulder line and then shave off a thin layer of waste, with the chisel held horizontally

and bevel-up.

- Repeat the procedure to cut the remaining pin boards.

3 - Gutting the rails

- Set a cutting gauge to the thickness of the pins, and then mark the shoulder line on all the tail boards.
- Place the first tail board outside-face down on the work exterior.
- Hold a pin board end-down with its inside face aligned with the shoulder line of the tail board, making certain the edges of the boards are flush.
- Outline the tails with a pencil, and then utilize a try square to extend the lines onto the end of the board.
- Mark all the waste sections with X-s.
- Then utilize a dovetail saw to cut the tails.
- Angling the board, rather than the saw, makes for easier cutting.
- Then secure the board edge-up in the vise and cut the waste beside the two outside tails.
- Eliminate the waste amongst the tails with a chisel utilizing the same technique described in step 2.
- When you have chiselled out half the waste, flip the piece and finish the job from the other side.
- Repeat the procedure to cut the other tail boards

4 - Test-fitting the joint

- Make a template with the desired pattern for the feet and trace the shape on one face of each board.
- Then, test-fit the half-blind dovetail joint.
- Mark any spots that bind with a pencil and cautiously pare some wood away at each mark until the fit is satisfactory.
- Cut the pattern in each of the feet freehand on the band saw.
- To keep the blade from binding in the kerf at the tight part of the curve, make a series of straight release cuts from the edge of the work piece to the marked line.
- Then, align the blade just to the waste side of the cutting line and

feed the work piece into the blade with both hands, making sure neither hand is in line with the cutting edge.

How to make the base molding

1 - Making the base pieces

- The four pieces that make up the base molding are fashioned and rabbeted individually.
- Working with stock longer than you need, rout one edge of the front and side pieces the same way you would shape cornice molding.
- Afterward, utilize your table saw to cut rabbets in all four pieces.
- The rabbets are sawn in two passes, with the shoulders first, followed by the cheeks.
- Adjust the blade height so the cheeks will be wide enough to support the chest without reaching the molding cuts; position the fence so one third of the stock thickness will be cut away.
- Utilize two feather boards to support the work piece; attach the table-mounted feather board to a shim so the middle of the work piece is pressed opposed to the fence.
- Feed each piece on edge into the blade until the trailing end reaches the table.
- Then move to the other side of the table and pull the stock past the blade.

2 - Gluing up the base

- Saw the molding pieces to length, cutting miters at both ends of the front piece and at one end of the sides.
- The front curves of the base are assembled with miter joints; butt joints are sufficient for the back.
- The connections should be reinforced with wood biscuits.
- Utilize a plate joiner to cut slots, then spread glue in the slots, insert biscuits in the front and back pieces, and press the curves together and clamp them.

3 - Fastening the feet to the base

- Working on a flat exterior, position the base on the feet of the

chest, making sure all the outer edges are flush.

- At each corner, bore four countersunk holes through the base and into the foot and screw the two together.
- Place the chest in the rabbets of the base piece and drive screws from underneath through the base and into the chest.

How to make ogee bracket feet

1 – How to cut the ogee cove

- Ogee bracket feet are created with an S fashioned ogee profile fashioned in their outside faces.
- As of their contoured exteriors, the two halves of each foot are joined with a miter and spline joint, rather than a half blind dovetail.
- The ogee profile is cut in three steps on the table saw and the router.
- Begin by marking the profile on the end of a piece of stock long enough to make all the feet.
- Set up your table saw to make a cove cut in the face of the board as you would for the cornice molding of an armoire.
- Utilize a push block to feed the stock, making several shallow passes to cut a cove of the appropriate depth.
- Once you have made the cove cut, utilize a router fitted with a rounding over bit to shape the corner of the board to the marked line.

2 – How to finish the ogee profile

- The ridge of waste amongst the cove cut and the rounding over cut is sliced off by the table saw.
- To set up the cut, hold the work piece on edge on the saw table and adjust the blade angle to align the cutting edge with the marked line on the board end.
- Butt the rip fence opposed to the stock, lock it in place, and set the blade height to slice away the waste.
- Utilize three feather boards to support the work piece while the cut.
- Clamp two to the fence and a third to the table; this feather board should be mounted on a shim so it will press closer to the middle of the stock opposed to the fence.
- Feed the work piece with both hands.
- Once the board's trailing end reaches the table, move to the other

side of the table and pull the stock past the blade.

How to assemble the ogee bracket feet

1 - Making the bevel cuts

- Since the ogee bracket feet will be assembled with miter and spline joints, each of the eight foot pieces will have bevels on adjoining ends.
- First, cut all the pieces fairly oversize.
- To cut the bevels, set your saw's blade angle to 45 degree and attach a wood extension to the miter gauge.
- Mark the length of a foot piece on your stock and, holding the flat edge of the board opposed to the extension, align the mark with the blade.
- Prior to making the cut, clamp a stop block to the extension to enable you to line up the cuts for the three other identical pieces.
- Hold the flat edge of the board opposed to the extension and the end opposed to the block as you make each cut.
- To bevel the ends of the four matching foot pieces, hold the contoured edge of the stock opposed to the extension as you make the cuts.

2 - Gutting the spline grooves

- The grooves for the splines in the beveled ends of the foot pieces are cut on the table saw.
- Install a dado head and adjust its thickness to that of the splines you will use.
- Set the angle of the head at 45 degree and shift the rip fence to the left-hand side of the blades.
- Holding one foot piece flat-face-down on the saw table, butt the beveled end opposed to the cutting edges of the dado head and adjust the fence and blade height so a 3/8 inch groove will be located about 1/4 inch from the bottom of the piece.
- Butt the fence opposed to the end of the stock and lock it in place.
- Feed each piece with the miter gauge, pressing the end opposed to the fence throughout the cut.

3 - Cutting the patterns and gluing up the feet

- Once all the spline grooves are cut, design the scroll patterns on the flat faces of the pieces and cut them out on the band saw.
- Sand the pieces smooth, then cut splines from plywood or solid wood to fit into the grooves.
- The splines should be as long as the grooves; make their width fairly less than twice the combined depth of two grooves.
- If you utilize solid wood for the splines, cut them so the grain runs across their width, rather than lengthwise.
- Spread adhesive in the grooves and glue up the feet, then attach them to the base as you would standard bracket feet.

How to install the lock

1 – How to outline the lock faceplate

- Lay the chest on its front panel and position the lock face-down midway amongst the sides and flush with the top edge of the panel.
- Trace the outline of the faceplate, and then extend the lines onto the top edge of the panel.

2 – How to route the lock mortise

- This is one of the rare instances in which the router is used to make a freehand cut.
- Care and patience are required.
- Utilize a wood chisel to first cut a shallow mortise for the faceplate lip in the top edge of the front panel.
- Afterward, install a straight bit in your router, set the cutting depth to the thickness of the faceplate, and cut a mortise inside the marked outline.
- Start by guiding the tool in a clockwise direction to cut the outside edges of the mortise; clear out the remaining waste by feeding the tool opposed to the direction of bit rotation.
- Utilize the chisel to square the curves and pare to the line.
- Measure the distance amongst the edges of the faceplate and the lock housing and transfer the measurement to the mortise.
- Adjust the router's cutting depth to the thickness of the housing and cut the final mortise.
- Utilize the chisel to square any curves.
- Test-fit the lock in the cavity and utilize the chisel to deepen or widen any of the mortises, if necessary.

3 – How to cut the keyhole

- Set the lock in the mortise and mark the place of the keyhole.
- Cut the opening as you would for an armoire lock, drilling one hole for the key shaft and another for the key bit.

- Utilize a small file to join the two holes.

4 – How to install the escutcheon

- Position the escutcheon on the front panel of the chest, aligning its opening over the keyhole.
- Utilize a strip of masking tape to hold the hardware in place while you start the nails in their holes.
- To protect your fingers when driving each nail flush, grip the nail shaft with needle nose pliers.

5 – How to mount the lock

- Once the keyhole is cut, lay the chest on its front panel again and set the lock in its mortise.
- Mark the screw holes on the panel, eliminate the lock, and bore pilot holes.
- Set the lock in place again and fasten it to the chest, driving the screw heads flush with the faceplate.

6 – How to install the strike plate

- Complete the lock installation by mounting the strike plate to the top of the chest.
- Slip the screws through their holes in the plate and set the plate on top of the lock.
- Turn the key until the lock engages with the strike plate, and then add a strip of masking tape to hold the plate firmly in place.
- Slowly close the top of the chest until its underside touches the screws.
- Bore a pilot hole at each mark left by the screw tips and attach the strike plate to the top.

How to install the flush handles

1 – How to outline the handles

- Lay the chest on one side and position a handle outside face down

midway amongst the front and back panels and a few inches below the top.

- Trace the outline of the mounting plate.

2 – How to mount the handles

- Install a straight bit in your router, set the cutting depth to the thickness of the mounting plate, and cut a mortise inside the marked outline as you would for a lock.
- Afterward, measure the distance amongst the edges of the mounting plate and the bowl fashioned housing and transfer the measurement to the mortise.
- Adjust the router's cutting depth to the thickness of the housing and cut the deeper mortise.
- Test-fit the handle in the cavity and utilize a wood chisel to pare any remaining waste wood from the mortises.
- Once the mounting plate rests flush with the outside face of the side panel, mark the screw holes, eliminate the handle, and bore a pilot hole at each mark.
- Set the handle in place again and fasten it to the chest.
- Repeat the procedure for the other handle.

How to install the inlay

1 – How to route the groove

- Grooves for inlay are cut with a router fitted with a straight bit the same width as the inlay.
- If you are installing shop-made inlay, set the cutting depth fairly shallower than the thickness of the strips; the inlay will be sanded flush.
- For commercial banding, which is very thin, make the cutting depth equal to the inlay thickness to minimize sanding.
- Outline the groove on the top with a pencil; it should be equidistant from the edges.
- Route the four sides of the groove individually, guarding the tool with an L-fashioned edge guide and stop blocks.
- To set up the guides, align the bit with the cutting line, measure the distance amongst the router base plate and the edge of the top, and cut the edge guide and stop blocks to that width.
- Screw a fence to each piece so it can be distance square to the edges of the top.
- For each cut, clamp the guide along the edge you will be cutting and fasten a stop block at each end.
- Holding the router's base plate opposed to the edge guide and one stop block, turn on the tool and plunge the bit into the stock.
- Feed the bit until the base plate contacts the other stop block.
- Once all the cuts are made, square the curves with a chisel.

2 - Setting the inlay in the groove

- Cut the inlay to length to fit in the groove, utilizing your table saw for shop made inlay, or a wood chisel for commercial banding.
- For the rectangular groove shown, make 45 degree miter cuts at the ends of the inlay pieces.
- Cut and test fit one piece at a time, then spread a little glue on the underside of the inlay and insert it in the slot, tapping the strip gently with a wooden mallet.
- Commercial banding should be held in place with masking tape

until the adhesive cures.

3 – How to trim the inlay

- Once the glue has dried, sand the top to eliminate any excess adhesive and bring the inlay perfectly flush with the exterior of the wood.
- For shop-made inlay, utilize a belt sander fitted with a 120-grit belt.
- Move the sander forward along one inlay piece, and pull the sander back when you reach the end of the strip, overlapping the first pass by one-half the width of the belt.
- Continue until the exteriors of the inlay and the top are flush, then move on to the other strips.
- Repeat the procedure with a finer belt about 150 or 180 grit to smooth the inlay and the surrounding exterior.
- Sand commercial banding by hand with a sanding block.
- Be cautious: Some modern banding is less than 1/20 inch thick.

Bonus Chapter How to select wood

Few decisions are as vital to building outdoor furniture as the choice of wood. The chart below rates several species in terms of resistance to decay, strength, capacity to withstand shock, working correctly, like planing and sanding or drilling, gluing, and fastening, and relative cost.

There is perhaps no one ideal choice. While a wood like teak combine strength with excellent decay resistance, it is very expensive, and hard to find and work.

Pine, on the other hand, is readily obtainable and economical, and is easy to work, but most species are highly susceptible to decay and rather weak. Numerous woodworkers contemplate native species with superior strength and decay resistance, such as cedar and white oak, to be an acceptable compromise.

Keep in mind that the same qualities that make a wood like teak tough on blades and cutters will yield sturdy furniture. Cedar, While it is more forgiving to blades and equipment, has a tendency to comprise a considerable number of knots, which increase waste and as well as the risk that the strength of the furniture will be compromised by a dead knot that was not cut out.

Knots are also more susceptible to rot. Whichever species you select, take the time to select your boards cautiously. Avoid lumber that is cupped, bowed, or warped in any way.

For maximum stability, select air dried lumber with a maximum of 20 percent moisture content. The wood should comprise as little sapwood as possible since the sap will attract wood-eating bugs.

Ordering lumber by the board foot

The "board foot" is a unit of measurement used to calculate the volume of a given amount of stock. The standard board foot is equivalent to a piece that is 1 inch thick, 12 inches wide, and 12 inches long. To calculate the number of board feet in a piece of wood, multiply its three dimensions together.

Then, divide the outcome by 144 if all the dimensions are in inches, or by 12 if just one dimension is in feet. So, if you had a 6 foot long plank that is 1 inch thick and 4 inches wide, you would calculate the board feet as follows:

$$1" \times 4" \times 6' = 12 = 2 \text{ (or 2 board feet)}$$

Recall that board feet are calculated on the basis of the nominal rather than actual dimensions of the stock; subsequently, the board feet comprised in a 2-by-4 that essentially measures 1 ½ by 3 ½ inches would be calculated utilizing the bigger dimensions.

Joinery

Joinery presents unique challenges to the outdoor furniture maker. Numerous of the standard Joints used for indoor furniture are incapable of withstanding the abuses wrought by weather.

The blind mortise-and-tenon joint, For instance, is typically an excellent choice for joining chair rails and legs, but it does not fare well outdoors. Water can become trapped in the mortise, causing the joint to swell and leading to wood decay.

A variation on the same joint, the through mortise-and-tenon, solves that issue by allowing water to drain out. Cutting angled shoulders helps prevent water from becoming trapped.

Lap joints and rabbet joints also work well. For extra protection opposed to water, you can coat the mating exteriors of joints with a preservative such as pine tar or an adhesive caulking compound.

Outdoor furniture makes frequent utalize of fasteners to connect components. Ensure you select ones that are either made from-or coated with-a metal that will not rust. Iron fasteners will ultimately weaken or break; they also stain the wood.

Glues play a vital part in most joinery, and here again, weather affects your choices. Standard yellow carpenter's glue is not waterproof and will ultimately fail when exposed to the elements. Instead, select a specialized glue intended for outdoor use, such as resorcinol and epoxy base adhesives. The former is fairly easier to use, but epoxy has useful gap filling correctly.

Finishing

The finish on any venture has two purposes: to beautify the wood and protect it. Nevertheless, if you have built your furniture from rot-resistant and stable wood, you may select to leave the wood uncompleted.

This cuts down substantially on maintenance, as once a finish is applied, it must be renewed periodically. Still, for the less decay-resistant woods, finishing is your best choice to protect the furniture from the elements and to keep insects at bay.

Also, some woods with little figure may look better covered with paint or a stain. A pigmented topcoat will also conceal any mismatched grain. The most common finishing choices are penetrating oils, varnishes, and paint.

Spar varnish requires that the first coat be thinned with undiluted varnish for the subsequent coats. Other finishes, especially paints, need a sealer first, followed by primer, then the finishing coats.

Water is not the only threat to outdoor furniture. Sunlight can damage wood by destroying the lignin in the wood, which fortifies the cell walls. If you want to shield the wood completely from the sun, utilize paint.

Generally, the higher the gloss, the better the protection, since the gloss will serve to reflect the sun's rays. Some finishes, such as spar varnish, comprise ultraviolet (UV) filters, which help shield the furniture from the sun's harmful radiation.

For maximum W protection, apply four or five coats. Lastly, do not expect a finish to salvage a poor building. While there are very expensive finishes obtainable, such as catalysed linear polyurethane, that will protect wood from virtually anything, including submerging it in water, the best way to ensure that your piece of furniture lasts is to start with the right joinery and glues.

BOOK 5

21

PROJECTS AND PRACTICAL TECHNIQUES
YOU SHOULD APPLY

Paul Berger

Chapter 1 How to build a side chair

Anticipating modern-day advertisers by more than 100 years, the Shakers proudly promoted their wares to a marketplace of non-believers who were nevertheless poised to purchase quality furniture.

As one of their early catalogues proclaimed, Shaker chairs offered "resilience straightforwardness, and lightness." The level of craftsmanship that they attained enabled them to back up their claims.

Shaker-made chairs sold well, proving that their business acumen was as well advanced as their piety. The Shakers had astutely reasoned that chairs were the right product for the market.

First, chairs required rather little stock to build-compared to case furniture-so they could be made economically. Furthermore, most models could be built quite rapidly, and they were compact and light enough for easy storage and transportation.

Lastly, chairs are a common household item; most buyers required several. All of these factors enabled their chair-making enterprise to contribute significantly to Shaker prosperity.

The following chapters will present step-by-step instructions for building three classic Shaker chairs. The Enfield side chair features a straightforward design that belies the fine craftsmanship and precise joinery required to build it.

Its legs, rails, and stretchers are turned on the lathe, and the pieces are connected with mortise-and-tenon joints.

The chair back consists of slats that must be steam bent. A traditional technique for forming the chair seat-woven rush-is will be discussed later. With its turned parts and mortise and tenon joinery, the rocking chair shares numerous features with the Enfield.

Nevertheless, the rear legs of the rocker, which are bent for comfort, and the rockers themselves fixed to the legs with dowel reinforced bridle joints-are elegant refinements. The chair is named after the community in upstate New York where prototypes were built.

Despite its traditional utilize as a pew for religious functions, the spindle-

backed meetinghouse bench has numerous contemporary applications. Each of these chairs early examples of which are still intact today embodies the Shaker belief "Build as though you were to live for a thousand years".

The most striking feature of the Enfield side chair is its backward slant of 98 degree. The design allows the chair to conform to the anatomy of the typical user and provide comfortable seating without needing steam-bent back posts.

The slant, nevertheless, does present a challenge in executing the joinery. Few of the joints in this chair are cut square; most are assembled at compound angles. It is a good idea to refer back to the side and top views as you build the chair, utilizing the angles to help set up your drill when boring the round mortises.

As an outcome of the seat's trapezoidal shape, the front legs are spaced farther apart than the rear ones. Also, the rear legs are splayed outward from bottom to top by 2 degree.

Consequently, the back stretchers, seat rail, and slats are progressively longer towards the top of the chair. To help you size and prepare the chair legs, mark key dimensions and the location of mortises on a shop-made story pole.

Made from a strip of plywood, the story pole embraces the length of the front and rear legs, and the placement of the stretcher, rail, and slat mortises. The marks on the jig can then be used to cut the leg blanks to length and outline the mortises on the blanks.

The mortises for the front or back stretchers or rails are offset $\frac{1}{2}$ inch lower than the mortises for the side ones to avoid weakening the legs. Label the story pole and keep it for future chair-making.

How to prepare the legs, rails and stretchers

1 – How to rout the slat mortises in the rear legs

- Outline the slat mortises on your rear leg blanks utilizing the story pole, centering the outlines on the inside face of each blank.
- Then secure one of the blanks amongst bench dogs.
- Install a ¼ inch mortising bit in a router equipped with an edge guide.
- Center the bit over the mortise outline and adjust the edge guide to butt against the stock; utilize the second leg blank to support the router.
- Make several passes, increasing the cutting depth with each pass until the mortise is completed to a depth of 5/8 inch.
- Repeat to rout the remaining mortises in both blanks, and then square the curves of the cavities with a chisel.

2 – How to turn the rear legs

- Place a rear leg blank amongst centers on your lathe, position the tool rest as close as possible to the work piece without touching it, and turn on the machine.
- Supporting a roughing gouge on the tool rest, cautiously move the bevel until it touches the blank and the cutting edge starts removing waste.
- Continue working all along the length of the blank until you form a cylinder, with the bevel rubbing and the tool pointing in the direction of the cut.

3 – How to turn the finials on the rear legs

- Start by cutting the cove that separates the finial from the cylindrical section of the leg.
- Use a roughing gouge at first, then switch to a spindle gouge.
- Holding the tool in an underhand grip and rubbing the bevel on the stock, slice into the wood and make a scooping cut down the middle of the cove.

- Switch to a skew chisel to shape the finial.
- Set the blade on the tool rest and advance it until it cuts into the stock.
- Shape the finial as desired, making sure the bevel is rubbing throughout the cut.
- Use sandpaper to shape the tip.
- Turn the other rear leg and its finial the same way.

4 – How to turn the rails and stretchers

- Turn the rails and stretchers as you did the rear legs, utilizing a parting tool to cut the tenons at the ends of each piece.
- Ensure a snug fit by making the diameter of the tenons equal to that of the bit you will utilize to bore the mortises.
- The tenon length should be one half the thickness of the legs.
- Lastly, turn the front legs.

How to make the slats

1 – How to steam the slats

- Set up a steaming jig.
- Also have a bending jig ready.
- Turn on the steam source and mark the center of each slat.
- Once steam begins to escape from the jig's drain hole, place a slat inside.
- Close the end cap firmly and let the wood steam until it is soft.
- As a rough guide, steam air-dried lumber for one hour per inch of thickness; half that time for green wood.
- Avoid scalding your hands by wearing work gloves and utilizing tongs to handle the stock.
- Place the slat in the jig and bend the steamed slat without delay

2 – How to bend the slats

- To make the bending form, center the mortises for the dowels along the length of the support boards.
- The distance amongst the two outside dowels should be rather less than the span of a slat when it is curved.
- As soon as you eliminate a slat from the steamer, rapidly fit it amongst the dowels.
- Center the slats against the middle dowel and push the ends behind the outside dowels.
- Alternate the direction of the slats to equalize pressure on the jig.

3 – How to prepare the slats for their mortises

- Let the slats dry in the bending form for a couple of days, then test-fit them in the rear legs and cut them to length.
- For a snug fit, sand the ends of the slats on a spindle shaper.
- Cautiously sand down the part of the back face that will fit into the mortise; confirm the fit periodically as you go.
- A gouge can also be used to cut away waste until you have a good

fit.

How to prepare the legs for the rails and stretchers

1 – How to prepare the front legs for the front rails and stretchers

- The only round mortises in the Enfield chair are drilled at 90 degree are those in the front legs for the front rails and stretchers.
- Use your story pole to outline the hole locations on the front legs and bore them on your drill press.
- Cut a V-fashioned wedge out of a wood block, creating a jig that will cradle the legs as you drill the holes.
- Install a bit the same diameter as the rail and stretcher tenons, and clamp the jig to the machine table so the bottom of the V is centered under the bit.
- Then place the leg in the jig and set the drilling depth to rather more than the tenon length about two-thirds the stock diameter.
- Holding the leg with one hand, bore the mortises.
- Repeat for the other front leg.

2 – How to prepare the rear legs for the back rails and stretchers

The mortises in the rear legs for the back rails and stretchers must be angled down by 2 degree to compensate for the slight splaying out of the back legs.

Set one of the legs upright in a bench vise, making sure it is vertical.

Use a protractor to adjust a sliding bevel to 92 degree.

Wrap a strip of masking tape around the bit to mark the drilling depth-about two thirds the leg diameter.

To help you hold the drill at the correct angle as you bore the hole, tape the handle of the sliding bevel to the leg and keep the bit parallel to the blade of the tool.

Stop drilling once the depth flag contacts the stock.

Repeat the procedure to drill the remaining holes in both legs, repositioning the leg in the vise and the sliding bevel on the leg as necessary.

3 – How to glue the front and back rails, stretchers

- Before drilling the holes in the legs for the side rails and stretchers, assemble the front legs and then the rear legs.
- Starting with the front legs, spread glue on the rail and stretcher tenons and in the leg mortises and fit the pieces together.
- Tap the joints into final position with a wooden mallet.
- Repeat for the rear legs, gluing the slats in place as well.

4 – How to prepare the legs for the side rails and stretchers

- The mortises in the legs for the side rails and stretchers must be drilled at compound angles they are angled in both the horizontal and vertical planes.
- Start by securing one of the rear legs in a hand screw and clamping the assembly upright to a work exterior.
- Then utilize the chair seat and side views, a protractor, and a sliding bevel to determine the drilling angle as you did in step 2.
- But instead of taping two sliding bevels to the stock, cut two square pieces of plywood, clamping one to the leg to indicate the vertical angle and the second to the rail or stretcher for the horizontal angle.
- For each hole, align the bit with the top edge of the vertical guide and the side edge of the horizontal guide.
- Again, stop drilling when the drilling depth flag contacts the stock.
- Utilizing similar techniques, drill the front leg assembly.
- Once all the mortises are drilled, spread glue on the tenons of the side rails and stretchers and in the mortises, and fit the pieces together.
- Use a wooden mallet and a wood block to tap all the joints into final position.
- Then set the chair upright.
- The four legs should all be flat on the floor.
- If not, you may have to apply firm but gentle twisting to one or more of the connections to coax the legs into position.

Chapter 2 How to make a rush seat

Early Shaker chairs, like the Enfield chair were completed with rush seats. Traditionally, the rush was natural, consisting of marsh grass twisted into a cord which was woven in a center diamond pattern over the frame.

Rush seats are both comfortable and durable, and can be done in an hour and a half for so once you get the knack. This section explains how to rush a chair seat with a more contemporary material tough grade, fiber paper twisted into long strands, known as fiber or manila rush.

Craft supply dealers are typically good sources of advice for the appropriate size and amount of rush required for a particular venture. Before starting, spray the individual lengths of rush with water to keep them pliable.

How to rush a chair seat

1 – How to bridge the front rail

- Since the rails that form the seat of an Enfield chair do not form a square, you must utilize rush to create a square seat frame.
- Measure the difference in length amongst the front and back seat rails and divide your measurement in half.
- Measure your outcome along the front rail from each of the front legs and make a mark on the rail.
- Tack a length of rather dampened rushing that is about twice the length of the front rail to the inside of a side rail about 2 inches from the front leg.
- Loop the rush around the front rail from underneath, then around the side rail from underneath.
- Bring the rush across the front rail and loop it around the other side rail and the front rail in the same manner.
- Holding the rush taut, tack it to the side rail opposite the first tack.

2 – How to square the seat frame

- Fasten a length of rush alongside the first one, utilizing the technique described in step 1.

- Loop it around the front and side rails, like the first strands, and fasten it to the opposite rail.
- Continue adding lengths of rush until you reach the offset marks you made on the front rail.
- Be sure to keep the rush as tight and straight as possible.

3 – How to weave a complete circuit

- Once you have squared the seat frame, you can begin rushing the seat all around the frame.
- Working with an approximately 20 foot length of rush, tack it to the side rail near the rear legs and loop it around all the rails.
- Keep working around the chair utilizing the same pattern.
- When you get to the end of a length of rush, clamp it temporarily to the seat frame to keep it taut and attach it to a new piece utilizing a figure eight knot.
- Locate the knots on the underside of the seat so they will not be visible.

4 – How to confirm the weave for square

- Once every third or fourth circuit, confirm whether the sides of the seat are perpendicular to each other.
- Holding the length of rush in a coil with one hand, butt a try square in one corner of the seat.
- The handle and blade of the square should rest flush against the rushing.
- If not, utilize a flat-tip screwdriver to straighten the side that is out of square, pushing the last circuit you installed against the adjacent ones.
- Repeat at the remaining curves of the seat.

5 – How to stuff the seat

- Once the rushing is about two thirds done, it is time to provide extra padding by stuffing the seat.
- To prevent the rush from slackening, utilize a spring clamp to

secure the loose length you are installing to a seat rail.

- Use cardboard for the padding, cutting one triangular piece for each side of the seat so that the triangle's long side is rather shorter than the seat rail.
- Slip the padding under the rushing, and then trim the tips if they overlap in the center.
- Continue the normal circuit as before until the two side rails are covered.

6 – How to complete the bridge

- Since the seat on an Enfield chair is deeper than it is wide, the rushing being installed on the side rails will meet in the middle of the seat before the rush on the front and back rails.
- Once this occurs, utilize a technique known as bridging to fill the gap.
- Loop the rushing on the front and back rails, passing the rush over the back rail, down through the center, under the seat and up around the front rail.
- Then bring the rush over the seat from the front rail and back down through the center.
- Pass the rush under the seat, come up around the back rail again and repeat the procedure.

7 – How to finish the job

- Once you have bridged the gap amongst the front and back rails, set the chair upside down on a work table and tack the last strand of rush to the underside of the back seat rail.
- Cut off the excess.

Chapter 3 How to make a shaker rocking chair

The rocker chair shares numerous features and building techniques with the Enfield side chair. For instance, the crest rail mortises in the rear legs are routed before the legs are turned and bent.

In this chair, the rear legs are bent from the arms to the top, instead of being canted back, as on the Enfield. The mortises for the back stretchers, rail, and slats are then bored with an electric drill; the mortises must be angled 2 degree to compensate for the outward splay of the legs from the bottom to the top.

Drilling the mortises in the legs for the other stretchers and rails is straightforward because there are no holes at compound angles. The mortises for the front rails and stretchers are 90 degree holes that can be bored on the drill press.

The mortises for the side rails and stretchers can be bored with a drill and shop made drilling guides; adjust the "TOP" guide to the appropriate angle, and set up the "SIDE" guide at 90 degree.

The front of the seat is wider than the back and the tops of the rear legs are farther apart at the top than the bottom. As an outcome, the rails and slats are progressively longer from the bottom to the top of the chair.

Like the rear legs, the slats are steam-bent for comfort. The front legs are parallel so the front rails and stretchers all share the same length. The side rails and stretchers are perpendicular to the legs in the vertical axis.

A comfortable angle is achieved by bending the rear legs, rather than inclining them. For balance, the rockers contact the ground 2 to 3 inches in front of the rear legs.

How to prepare the rear legs

1 – How to bend the legs

- Rout the crest rail mortises in the rear legs, turn them on your lathe, then steam the legs for bending.
- To bend them to the appropriate arc, utilize a shop-made jig.
- For the jig base, cut a piece of plywood longer than the legs, and then make the bending form from a piece of solid stock rather denser than the leg diameter.
- On your band saw, cut the desired curve about 10 degree - on both edges of the form, starting the cut about halfway up the board.
- Then screw the form to the base and fasten a stop block on each side of the straight portion of the form; the gap amongst the blocks and the form should equal the leg diameter.
- As soon as you take the legs from the steamer, set them on the jig amongst the form and the blocks, aligning the point on the legs that will be joined to the seat rails with the start of the curved cut on the form.
- Then, protecting the stock with wood pads, install a bar clamp just below the slat mortises to bend the legs snugly against the form.
- Secure the top of the legs against the form utilizing a hand screw.

2 – How to prepare the legs for the rockers

- Once the legs are dry, mark holes for the screws that will fasten the legs to the rockers; locate a hole on each leg about 1 inch from the bottom end.
- Cut a V-fashioned wedge out of a wood block, creating a jig that will hold the legs as you bore the holes.
- Clamp the jig to your drill press table so the bottom of the V is centered under the bit.
- Then place the leg in the jig and align the marked point with the bit.
- Holding the leg with one hand, bore a countersunk hole three quarters of the way through the stock.
- Then outline a notch on the bottom end of each leg perpendicular

to the hole, making its width equal to the thickness of the rockers and its height about one-half the rocker height.

- Cut the sides of the notches on your band saw, and then eliminate the waste amongst the kerfs, shaving away the wood in thin layers with a chisel.
- Clamp a stop block in place with an arc cut out of one face to steady the work piece.

How to prepare the arms and the rockets

1 – How to cut the arms and rockers

- Make a template for the arms.
- Outline the shape on one arm blank, then flip the template over and outline the second arm; this will ensure that the two are mirror images of each other.
- On each arm, also mark the mortise that will accept the tenon at the top end of the front leg.
- Cut the arms to shape on your band saw.
- Repeat the procedure to saw the rockers.

2 – How to prepare the arms for assembly

- While the tenons at the ends of round parts of the chair-like the legs, rails, stretchers and slats can be done on the lathe, the tenons at the back end of the arms cannot be turned.
- Instead, install a dowel cutter on your drill press, tilt the machine table 90 degree and clamp the arm in place with the tenon end centered under the cutter.
- Set the drilling depth at one-half the leg diameter then cut the tenon.

How to assemble the chair

1 – How to glue the front and rear leg assemblies together

- Gluing up the rocking chair follows much the same procedure used for the Enfield chair.
- Start by attaching the crest rail, slats, rails and stretchers to the two rear legs.
- Then glue the arms, rails, and stretchers to the front legs.
- Once the adhesive has cured, spread glue on the tenons of the side rails and stretchers and in their mortises in the legs and fit the two assemblies together.
- Use a dead-blow hammer to tap the joints into final position.

2 – How to make the arm buttons

- Prepare two blanks and drill a mortise halfway through each one sized to accept the tenon at the top end of the front legs.
- Glue a length of dowel in each hole, and then utilize the dowel to mount one of the blanks on your lathe.
- Turn the button to shape, and then smooth it with sand paper while it is still spinning on the lathe.
- Eliminate the button from the machine and drill out the dowel.

3 – How to install the arm buttons

- Once both arm buttons are ready, spread glue in their mortises and on the tenons at the top end of the front legs.
- Then position the buttons on the arms.

4 – How to attach the legs to the rockers

- Set the rockers on a flat exterior and position the chair on them so the rear legs sit about 2 inches behind the point where the rockers contact the exterior.
- Use a chisel to shape the bottom of the notches in the legs so they lie perfectly flat on the rockers, and then mark the screw holes on

the sides of the rockers, utilizing the holes in the legs as a guide.

- Eliminate the chair and drill a hole at each mark, set the chair upside down, and reposition the rockers on the chair.
- Now screw the less and rockers together.

Chapter 4 How to make a tape seat

Shaker tape's range of colors, neat appearance, resilience, and ease of installation made it ideal for furniture builders bent on producing quality goods as efficiently as possible.

And unlike cane or other naturally occurring supplies, tape does not dry out or split; nor does it pinch or snag clothing. One length of tape, called the warp, is anchored to the side rails and wrapped around the front and back seat rails in adjoining rows.

A second length, called the weft, is woven alternately under and over the strands that form the warp. Loose ends are joined by weaving them back on themselves, ensuring that the rows always remain parallel.

Shaker tape is obtainable in 5/8 and 1 inch widths from folk art suppliers. You can weave the basic tabby style or create a wide diversity of designs that embrace basic and complicated geometric shapes.

How to weave a tape seat

1 – How to anchor the warp rows

- Tack a length of tape to the inside of a side seat rail about 2 inches from the rear leg so that the tape is parallel to the rail.
- Loop the tape around the back rail from underneath, ensuring the edge of the material butts against the rear leg.
- Wrap the tape around the front rail and pull it towards the back rail from underneath.

2 – How to stuff the seat

- Continue wrapping the warp around the front and back rails from underneath, making sure adjoining rows of tape are in contact.
- The weave should be tight, but not so taut that there is no play for the weft rows to be woven amongst the warp rows.
- Once you are about halfway to the opposite side rail, it is time to stuff the seat.
- To prevent the tape from slackening, tie the loose length of tape to

one of the slats.

- Buy a piece of 1 inch-thick foam padding from a craft supply or hardware store and cut it with a craft knife to fit within the seat rails.
- Slip the padding amongst the tape layers, centerline it amongst the rails.

3 – How to complete the warp

- Continue weaving the warp rows until you reach the opposite side rail and the back seat rail is exclusively wrapped in tape.
- Then temporarily tack the loose length of tape to the side rail and cut off the loose end.

4 – How to start the weft

- Set the chair upside down on a work exterior that will enable you to work comfortably.
- Starting along the back seat rail opposite the place where you began the warp, slip the end of the weft tape under the first strand of the warp, over the Then, and continue with this under-and-over weave until you reach the last warp strand.
- Pull the excess tape through, leaving 5 inches or so at the starting point.
- Weave this part back on itself to anchor the tape in place.
- Flip the chair upright and continue weaving on the top side of the seat.

5 – How to fill the gaps in the warp

- Weave about three rows of weft, then begin filling in the triangular gaps left along the side rails where you installed the warp.
- Cut a length of warp tape long enough to weave two rows of seating, plus about 5 inches, and slip the tape under the last strand of weft beneath the seat and around the front seat rail, butting it against the last row of warp you wove in step 3.
- Then return to the back rail, passing the tape under the last weft

row and over the second one.

- Weave another warp row adjacent to the last one the same way.
- Leave the excess hanging for now; you will be able to weave it into the subsequent weft rows.
- Weave three more weft rows and repeat the gap-filling procedure

6 – How to complete the weft rows

- Continue weaving the weft, wrapping each row around the side rails and weaving over and under the warp rows.
- Avoid twisting the material.
- As you finish each row, pull it tight against the previous one with your fingers.
- As you work your way toward the side rail, the warp will become increasingly tight.
- To make space for the weft, slide a blunt knife amongst the warp rows as necessary.
- When you have laid down the final weft row, weave it back on itself to hold it in place.
- Also weave in any loose ends of tape on the underside of the seat.

7 – How to splice tape

- If you run out of tape before finishing the warp or the weft, you will need to join two ends.
- You can stitch them together with thread, but a straightforward technique is to start weaving a new length at a point about 6 inches before the end of the first tape, overlapping the tapes and binding them together by friction.
- Use this technique on the underside of the seat with the chair upside down so that no seams or bulges will be visible.

Chapter 5 How to make a meeting bench

While numerous Shaker communities had meeting benches of the style discussed in this section, the design is believed to have originated in Enfield, New Hampshire.

Typically, the crest rail, legs, and spindles were built from maple or cherry and the seat from pine. Numerous early examples remain intact, as an outcome of sound building and cautious handling by their makers.

The bench's legs are raked to the front and back, but are not splayed sideways. The spindles and crest rail are tapered and the rail is angled at the ends.

Requirements:

- Seat: Quantity: 1, Length: 44 inches, Width: 14 inches, Thickness: 1 1/2 inches
- Crest rail: Quantity: 1, Length: 44 inches, Width: 4 inches, Thickness: 3/4 inches
- Spindles: Quantity: 11, Length: 14 inches, Width: 3/4 inches
- Legs: Quantity: 4, Length: 17 inches, Width: 1 1/2 inches
- Stretchers: Quantity: 2, Length: 14 inches, Width: 3/4 inches

How to prepare the seat

1 – How to drill the leg holes

- Clamp your seat blank bottom-face upon a work exterior and mark a reference line across the exterior 5 inches from each end, and then pinpoint the holes for the legs; the back holes should be 1 1/2 inches from the back edge of the seat and the front holes should be 1 3/4 inches from the front edge.
- Fit a hand brace with a spoon bit the same diameter as the legs.
- To help you drill the holes at the correct rake angle, make two guides from a short wood scrap, mitering the guide for the front legs at 5 degree and the one for the back legs at 15 degree.
- Set the appropriate guide on edge on the reference line a few inches from the hole mark and hold the bit parallel to the mitered edge of the guide.

- Then bore the hole, stopping when you are about two thirds of the way through the stock about 1 inch deep.

2 – How to drill the spindle holes

- Bore the holes for the seat spindles utilizing your drill press and a shop-made jig.
- Mark a reference line on the top face of the seat parallel to the back edge and 1 inch away from it.
- Then mark the spindle holes, starting about 2 ½ inches from the ends and spacing the remaining holes equally.
- To ensure that the spindles are tilted back at the correct angle, adjust a protractor to 10 degree and utilize the shop-made tilted table jig to tilt the seat in relation to the bit.
- For the jig, set a piece of plywood on the machine table, place the seat blank on top, and slip a 2 by 2 under the plywood parallel with its back edge.
- Holding the protractor base on the seat and the blade then to the bit, reposition the 2 by 2 until the blade is parallel to the bit.
- Then screw the 2 by 2 the plywood and clamp the jig to the machine table.
- To drill the holes, set the drilling depth at two thirds the seat thickness, align the first mark under the bit, and clamp a board to the jig as a fence along the seat front's edge.
- Then, holding the seat against the fence, bore each hole.

3 – How to prepare to shape the seat's top

- Cut the recess on the seat's top exterior on your table saw.
- Start by marking the profile of the seat on the work piece.
- Referring to the requirements, outline the shape of the ends on the bottom face and end grain of the blank.
- To outline the recess, set the seat top face down on your table saw and crank the blade to the desired depth of cut.
- Position the seat so the recess will be centered amongst the middle and the back edge, then outline the blade on the end of the stock and mark a reference line on the saw table along the seat's front

edge.

- Now clamp a board as a guide so that its edge is aligned with the reference line.

4 – How to cut the recess in the seat top

- Adjust the blade to a cutting height of 1/16 inch.
- Slowly feed the seat across the table with one hand, while pressing it against the guide board with the other.
- Make as numerous passes as necessary until the blade outline on the end of the stock dissembles, raising the blade 1/16 inch at a time.
- For a smooth finish, raise the blade very rather and make a final pass.

5 – How to shape the top of the seat

- Clamp the seat face-up on a work exterior and mark a guideline along the length of the recess you cut as a reminder of where the curved portion of the seat top will end.
- Referring to the requirements, utilize a hand plane to finish shaping the seat top, removing waste from end to end and always cutting with the grain.
- Continue until you reach your outline.

6 – How to cut the ends of the seat

- Following the cutting lines on the top face of the seat, cut ends on your band saw.
- Keep the work piece flat on machine table as you feed it, then sand the cut ends smooth.

7 – How to shape the underside of the seat

- The ends and front edge of the seat are beveled on its underside.
- Bevel the front edge of the seat on your table saw, tilting the blade to a 45 degree angle.
- The ends are best fashioned by hand with a carver's drawknife.

- Clamp the seat face down on a work exterior.
- Then, holding the tool in both hands with the blade bevel-down at a 45 degree angle to the end of the seat, pull it toward you to shave off waste wood.
- Once you are satisfied with the bevel, sand the ends smooth.

How to join the legs to the seat

1 – How to prepare the legs for the stretchers

- Turn the legs on your lathe, tapering them to a diameter of $\frac{3}{4}$ inch at the top and $\frac{15}{16}$ inch at the bottom.
- Also turn the stretchers into cylinders, forming a tenon at each end.
- To ensure that the stretcher holes in the legs will be at the correct angle, drill them with the seat face-down on a work exterior and the legs dry fitted in their holes in the seat.
- Install a spade bit in an electric drill and wrap a strip of masking tape around the bit to mark the drilling depth about one half the diameter of the leg.
- Also mark a point halfway up each leg.
- Then holding the leg in its hole and the bit parallel to the seat exterior, drill the hole at the mark, stopping when the masking tape contacts the stock.

2 – How to prepare the legs and stretchers for wedges

- Reinforce the joints connecting the legs to the seat and the stretchers to the legs with wedges.
- Cut the kerfs for the wedges on your band saw.
- When you are kerfing the legs, hold the leg on the machine table with the stretcher hole facing straight up.
- This will ensure that the wedges in the legs are perpendicular to the grain of the seat, preventing the seat from splitting.
- Feed the work piece into the blade, slicing a kerf to a depth of about $\frac{1}{2}$ inch.
- Cut the kerfs in the stretchers the same way, making sure that the wedges will be perpendicular to the grain of the legs.

3 – How to glue up the legs and stretchers

- To make wedges for the kerfs, cut some hardwood pieces on the band saw rather less than $\frac{1}{2}$ inch long and $\frac{1}{8}$ inch thick at the

base, tapering to a point.

- Start by gluing the stretchers to the legs.
- Spread some adhesive on the wedges and in the kerfs as well as on the stretcher tenons and the mortises in the legs, and insert the wedges into their kerfs.
- Fit the stretcher and legs together, utilizing a wooden mallet to tap the pieces into final position.
- You can leave the wedges protruding from the kerfs; they will sit flush with the ends of the legs and stretchers when you tap the joints together.
- Then, glue the wedges into the legs, spread adhesive on the contacting exteriors amongst the legs and the seat, and tap the legs into position.

4 – How to saw the legs to length

- The technique described will ensure that all four legs are precisely the same length.
- Cut four wood blocks from a single board, then notch one of the blocks to fit around a leg.
- Place the block around the first leg to be cut.
- Holding the leg firmly with one hand, cut it to size with a flush-cutting saw.
- Once the first leg is trimmed, eliminate the notched block and replace it with one of the remaining blocks.
- Position the notched piece around the Then leg and make the cut.
- Continue in this way until all four legs are cut.
- If you want the bench to have a backward slant, tack shims to the bottoms of the front legs before trimming the legs.

How to glue the crest rail and spindles to the seat

1 – How to prepare the crest rail for the spindles

- Cut the crest rail to size, and then mark the spindle holes on its bottom edge, utilizing the holes you drilled in the seat as a guide.
- Clamp a piece of plywood as an auxiliary table to your drill press, install a brad-point bit, and adjust the drilling depth to about 1 inch.
- Align the first hole mark under the bit and clamp a board to the auxiliary table flush against the face of the rail.
- This will serve as a fence to position the rail.
- Butting the rail against the fence, drill the holes.

2 – How to glue up the spindles and crest rail

- Set the seat face up on a work exterior, and then spread glue on the ends of the spindles and in the holes in the seat and the crest rail.
- Fit the spindles into the seat, tapping each one into final position with a dead-blow hammer.
- Once all the spindles are in place, fit the rail on top and tap it into position.
- For supplementary reinforcement, you can peg the joints amongst the spindle and the seat and rail at each end of the bench.
- Drill the peg holes into the spindles through the back edge of the seat and the outside face of the rail.

Chapter 6 How to make a trestle table

Trestle tables were common fixtures in most Shaker dining halls. With their narrow legs and unobstructed legroom allowing people to sit quite close together, the tables were well suited to the Shaker ethic.

To facilitate the passing of food across the large tops, settings were divided into "squares" of four diners. Typically 10 feet long, Shaker trestle tables were built to seat three squares of 12 people.

The 6 foot long table seats eight comfortably. Drop leaf tables, with their expandable tops, were advanced later than trestle types, becoming common by 1820.

They were used in the dining hall as side tables or, often, as dining tables. But the drop leaf design is so practical that the Shakers found a multitude of applications for it everywhere from the dairy to the infirmary.

The pedestal table, or candle stand, was very popular with the Shakers. Robust and sturdy, it was light enough to move simply. Its tripod legs kept it from wobbling.

The Shakers experimented endlessly with this basic form. The stand was built with convex, concave, or turned legs. Tops were made round, square or rectangular.

Every so often, the tops were simply rounded over or lipped, and some featured under slung drawers to hold sewing supplies. Some tops had a groove in the lip to help in the packaging of seeds.

Oval or octagonal shapes were excluded, nevertheless, as being frivolous and too worldly. The candle stand discussed in this chapter is but one version of a popular and functional design.

Despite their large size, trestle tables are easy to move. This is because the joints connecting the feet to the legs, the legs to the rails, and the rails to the top are fixed not by glue, but by screws and bolts.

It relies heavily on knockdown hardware, a modern version of the Shaker practice of assembling tables with bolts that drew against a trapped nut, allowing easy disassembly.

Shakers often used cherry for their tables; this remains a good choice today.

To prevent the top from warping and also to hide end grain, a tongue is cut along each end to position the mating groove of a breadboard end.

The ends are screwed to the top, with just a little glue applied at the middle. This allows the top to expand and contract across its width as humidity changes without being hindered by the breadboard ends.

The first step in making this table is gluing up the top. Because of its width, the top cannot be passed through most thickness planers after glue up.

Instead, start by assembling the top in the largest possible sections that your machine can handle and plane them to a uniform thickness. Then glue the sections together, being very cautious to ensure that they are perfectly flush.

How to make the top

1 - Applying the glue

- Once all your boards are jointed and ripped to a combined width that is roughly 1 inch wider than the completed top, arrange the boards for the best possible match of color, figure, and grain.
- To minimize warping, lay out the planks so that the end grain of adjacent boards runs in opposite directions, and then mark a reference triangle on top of the boards.
- This will help you correctly realign them for glue up.
- To hold your bar clamps upright, cut notched wood blocks and set the clamps in the blocks.
- Space the clamps every 24 to 36 inches.
- To protect the stock, also cut two wood pads as long and as thick as the planks.
- Apply a narrow bead of glue to one edge of each joint and utilize a small, stiff-bristled brush to spread the adhesive equally on the board edges.

2 – How to tighten the clamps

- Lay the boards face up on the bar clamps and align their ends, making sure the sides of the reference triangle are lined up.
- Tighten the clamps under the boards just enough to butt them together.
- To balance the clamping pressure and keep the panel flat, place bar clamps across the top of the panel amongst the ones underneath.
- As you tighten the clamps, ensure that the boards are perfectly flush.
- Place a scrap of wood on any high spots where two boards meet and hit it with a hammer until the two lie flat.
- Finish tightening all the clamps in turn until there are no gaps amongst the boards and a thin, even bead of glue squeezes out of the joints.
- Once all the top sections are glued up, plane them and glue them

together.

3 - Preparing the top for the breadboard ends

- The breadboard ends are attached to the top with a tongue-and-groove joint.
- Start by routing a tongue at each end of the top.
- Install a piloted three wing slotting cutter in a router and set the cutting depth to $\frac{1}{4}$ inch; this will enable you to clear the waste from each side of the tongue in two passes.
- Secure the top to a work exterior and turn the router on with the bit clear of the stock.
- Make the first pass on both sides of each end making sure the bit's pilot bearing is butted against the end of the top.
- Then rearrange the depth of cut rather deeper to rout the rest of the waste from half of the tongue; the tongue should be one-third the thickness of the top.
- Finish the tongues at both ends.

4 – How to make and install the breadboard ends

- Plane the breadboard ends to the same thickness as the top, then saw them as long as the top's width.
- Cut the grooves along the inside edges of the breadboard ends on your table saw.
- The grooves should be as wide as the tongues you routed in step 3 and rather deeper than their length.
- Fit the ends in position and counter bore three holes through each one and into the top, locating one hole at the middle and another a few inches from each end.
- Use a file to elongate the holes in the breadboard ends rather; this will facilitate wood movement.
- Spread glue on the tongues about 1 inch to each side of the center, then reposition the breadboard ends, utilizing a mallet and a wood block, if necessary, to tap them into final position.
- Drive the screws to secure the ends, glue wood plugs over the heads, and trim them flush with a chisel.

- Sand the exterior smooth.

How to make the feet

1 - Preparing the feet for the legs

- Outline the feet on blanks and cut the mortises in them with a router and the commercial mortising jig.
- The jig features two guide pins that butt against opposite faces of a work piece, ensuring that the mortise is centered on the edge.
- Install a ½ inch mortising bit in a router and set the cutting depth to cut the 1/8 inch-deep mortise in three or four passes.
- Secure one foot edge up on your bench and mark the beginning and end of the mortise.
- Plunge the bit into the stock at one end of the mortise, and then feed the cutter to the other end, making sure the guide pins both ride along the work piece throughout the cut.
- Repeat for the other foot, and then square the curves of the mortises with a chisel.

2 - Sawing the feet to shape

- Cut the leg on your band saw, sawing the top edge first, followed by the bottom edge.
- Sand the cut edges smooth

3 – How to chamfer the top edges of the feet

- Install a piloted 45 degree bit in a router, mount the tool in a table and set the cutting depth for a ½ inch-wide chamfer.
- To prevent kickback, clamp a notched guide board to the table so its edge is in line with the bit's pilot bearing.
- Reinforce the guide with a support board.
- To indicate where the chamfer ends, mark a line across the top edge of the foot ¾ inch from each end of the mortise.
- Feed the foot into the cutter, riding the stock along the guide board to start the pass, then pivot the work piece away from the guide, making sure the stock butts against the bearing.
- Stop the cut at the chamfer line.

- Repeat on the other side of the mortise, then turn the foot over and chamfer the opposite face.

How to make the legs and rails

1 – How to saw the tenons at the bottom of the legs

- Cut the legs to size, and then outline the tenons on their bottom ends, utilizing the mortises in the feet as a guide.
- Cut the tenons on your table saw fitted with a dado head; adjust the width of the head to rather more than one-half the tenon length-about 1 inch.
- You will saw the tenon sides and edges in two passes each, eliminating the need to attach an auxiliary fence.
- To position the rip fence, align the shoulder line on the leg with the dado head and butt the fence against the end of the board; the fence should be well clear of the blades.
- Start by cutting the sides of the tenon.
- For the edges, align the end of the board with the dado head and make a pass, and then turn the leg over and repeat.
- To complete the tenon, align the shoulder line with the head and feed the board with the miter gauge, riding the end of the work piece against the fence.
- Turn the board over and repeat.

2 – How to prepare the legs for the trestle

- The trestle fits into a stopped groove at the top of the leg.
- Adjust the width of the dado head and the cutting height to 5/8 inch.
- Center the face of the leg over the dado head and butt the fence against the edge.
- Mark the end of the groove on the legs and the points on the table insert where the blades stop cutting; this will help you determine the position of the dado head when it is hidden by the work piece while the cut.
- To saw the groove, feed the leg face down, holding the edge against the fence.
- Once the cutting line on the leg aligns with the mark on the table insert, lift the work piece off the dado head.

- Square the stopped end of the dado with a chisel.
- You can now cut a two-shouldered tenon at each end of the stretcher to fit into the groove.

3 – How to prepare the rails for the legs

- The rails are attached to the top ends of the legs with bridle joints.
- Start by cutting the recesses in the rails that enable them to mesh with the mortises you will saw in the legs.
- Outline the rail profile on your blanks and mark the shoulders of the recesses 2 inches to each side of the middle of the boards.
- Adjust the dado head on your table saw as wide as it will go and set the cutting height at $\frac{1}{4}$ inch.
- Screw an extension to the miter gauge, align one of the shoulder marks on the rail with the dado head, and butt the fence against the end of the stock.
- Feed the rail with the miter gauge, pressing the stock against the fence.
- Flip the rail to cut a shoulder on the other face, then rotate the piece and cut the shoulders at the other end of the recesses.
- Move the fence out of the way and eliminate the remaining waste.

4 – How to saw the mortises in the legs

- Replace the dado head on your table saw with a combination blade, crank it as high as it will go, and cut the mortises at the top ends of the legs with the help of a commercial tenoning jig.
- Clamp the leg upright in the jig, position the jig to center the blade on the edge of the work piece, and feed the stock into the cut.
- Then move the jig very rather away from the blade to enlarge the mortise.
- Make another pass, turn the leg around in the jig, and feed it into the blade again.
- Then, test fit one of the rails in the mortise.
- If the fit is too tight, adjust the jig to shave a little more wood from the mortise and make two more passes, continuing until the rail fits snugly in the mortise.

5 – How to cut the rails to shape

- To bring the top edge of the rails flush with the top end of the legs, you will have to notch the bottom edge of the recessed section of the rails.
- Fit the rail upside down in the leg mortise and draw a pencil along the top of the leg to mark a cutting line across the rail.
- Cut the notch on your band saw, starting with straight cuts along the shoulders of the recess to the marked line.
- Eliminate the remaining waste by making a curved cut from the edge to one shoulder, then rotate the board 180 degree and saw along the cutting line.
- Once the notches in both rails are ready, saw the rails to shape as you did the feet and sand the exteriors smooth.

How to assemble the table

1 – How to prepare the rails for the top

- To allow the table top to move, the rails are fastened to it with screws rather than glue.
- Mark six screw holes along the top edges of the rails-three on each side of the recesses and bore them on your drill press.
- Holding the rail upright on the machine table, drill a counter bored hole through the work piece at each mark; utilize curved backup boards to help you steady the rail.
- Then turn the rail over and enlarge the bottom of each hole, utilizing a $\frac{1}{2}$ inch diameter bit.
- This will facilitate wood movement.
- Do not drill too deep, Nevertheless; for appropriate anchoring, a screw requires at least 1 inch of wood with a hole no larger than its shank.

2 – How to prepare the feet for the legs

- Utilizing two different bits on your drill press, bore a hole through each foot for the bolt that will attach it to the leg.
- The bolt will be threaded into a cross dowel to provide long-grain support (step 4).
- Start by drilling a hole to conceal a bolt head with a $1 \frac{3}{4}$ inch spade bit.
- Mark a line on the face of the foot $1 \frac{3}{4}$ inches from the bottom edge to indicate the drilling depth.
- Holding the foot upside down on the machine table, utilize the line as a guide for setting the drilling depth, then bore the bolt-recessing hole.
- Then switch bits and bore a $\frac{3}{8}$ inch-diameter clearance hole for the bolt through the foot.

3 – How to drill clearance holes in the legs

- Use an electric drill to prepare the legs for the bolts from the feet.

- Start by fitting a foot and leg together and secure the assembly upside down in your bench vise.
- Insert a pencil into the hole in the foot and mark its center on the tenon at the end of the leg.
- Then eliminate the foot and utilize the drill fitted with a 3/8 inch spade bit to bore into the tenon and leg to a depth of about 3 inches.
- Keep the tool perpendicular to the end of the tenon throughout the operation.

4 – How to bore clearance holes in the legs for cross dowels

- Install a 7/16 inch brad point bit your drill press and set the leg inside on the machine table.
- Adjust the drilling depth to rather less than the stock thickness.
- To locate the hole for the cross dowel, mark a vertical line along the leg aligned with the pilot hole and a horizontal line across the leg $\frac{3}{4}$ inch from the shoulder of the tenon.
- Holding the leg steady, drill the hole.

5 - Bolting the feet to the legs

- Now you are ready to assemble the table, starting with the feet and legs.
- Fit the pieces together and set the assembly on a work exterior.
- Slip the cross dowel into its hole in the leg and insert the bolt up the foot.
- To align the fasteners so the bolt engages with the dowel, hold the dowel in position with a screwdriver as you drive the bolt with a hex driver or wrench.
- Once the bolt catches in the dowel, tighten it firmly.

6 – How to assemble the legs, rails and trestle

- Notch the trestle for the cleat, then screw the cleat in place.
- Clamp the cleat to a work exterior, fit the legs and rails together, and position the legs against the trestle.

- The legs and rails are joined to the trestle with bolts and cross dowels.
- To make the connections, drill two pilot holes for bolts through each leg and rail into the end of the trestle.
- Locate the holes so they pass through the rail, rather than below it, in the notched portion of the stock.
- Then, bore two holes near each end of the trestle for cross dowels as you did in the leg, then bolt the legs and rails to the trestle.

7 – How to prepare the top

- Before fastening the top to the rails, round over its top and bottom edges and ends.
- Lay the top face up on a work exterior and start by rounding the curves rather with a sanding block.
- Then install a piloted $\frac{1}{4}$ inch round-over bit in a router and set the depth of cut to shape the top's edges in two passes.
- Press the bit's pilot bearing against the stock as you feed the router counter clockwise along the edges and ends of the top.
- Turn the top over and repeat the procedure with a $\frac{1}{2}$ inch round-over bit to shape the bottom edges and ends.

8 – How to attach the top to the rails

- Leave the top face down on the work exterior and position the rail-and-leg assembly on it.
- Use an awl to mark the screw holes through the rails on the underside of the top, and then drill a pilot hole for a screw at each point.
- Ensure the bit does not penetrate the top's upper exterior.
- Reposition the rails on the top and screw them in place.

Chapter 7 How to make a drop leaf table

The leaves could be raised when a wider top was required, and folded down afterward so the table would occupy less space. Shaker drop leaf tables ranged from 10 foot-long dining tables, every so often referred to as "harvest tables," to small work tables just 2 feet long.

At 41 inches long table, is a comfortable compromise. The top can expand to a width of more than 3 feet, seating four people comfortably. With the leaves folded down, the table is less than 20 inches wide.

To ensure adequate support for the leaves, utilize the largest drop-leaf hinges obtainable, which are typically 1 ½ by 2 7/8 inches.

How to make the legs

- Cut the four legs to size, then chop mortises by hand, or utilize a drill press equipped with a mortising bit.
- The mortises should be 3/8 inch wide and 7/8 inch deep, leaving space for ½ inch shoulder on the tenon at each end.
- Then, turn the legs to the required shape.
- To help you develop four identical legs, make a hardboard template of the taper.
- The template should indicate the completed diameter of the legs at several different points along their lengths.
- Start by separating the pommel, or square section, from the cylindrical section.
- Mark the pommel line on the leg blanks, then mount one of them on your lathe. Define the pommel with a roughing gouge.
- Cut a notch at the marked line, then round the curves of the blank below the pommel.
- With the tip of the gouge tilted up, gradually raise the handle until the bevel is rubbing against the stock and the cutting edge is slicing into the wood.
- Work from below the pommel toward the bottom of the leg, continuing until the blank is cylindrical and smooth.
- Form the taper with a spindle gouge, adjusting a separate set of calipers for each of the dimensions as marked on your template.

- Then confirm the diameter of the blank at the appropriate points.
- Deepen the cuts if necessary until the measurements on the template and the diameter of the cuts are equal.
- Repeat for the remaining blanks.

How to prepare the rails:

1 - Making the drop-leaf supports

- The drop leaves are supported by pivoting supports.
- Housed along the top edge of the side rails, the supports pivot on dowels to hold the drop leaves when they are extended, then align with the rails when the leaves are not required.
- Rip a 7/8 inch wide strip from the edge of each side rail, then adjust your table saw's miter gauge to a 70 degree angle.
- Cut a 10 ¾ inch-long piece from each end of the strip.
- The piece amongst the cuts will be the drop-leaf support; the two end pieces will be glued back onto the side rail (step 2).
- Make the other support the same way.

2 - Reassembling the side rails

- Lay four bar clamps on a work exterior and set one of the side rails on top.
- Spread glue on the contacting edges of the outside strips you cut in step 1 and the rails, and press the strips in place.
- The rail should extend beyond the end of the strips by about 1/8 inch-the width of the saw cuts made in step 1.
- The rails will be trimmed later.
- Protecting the stock with wood pads, tighten the clamps until a thin glue bead squeezes out of the joints.
- Immediately position the drop-leaf support amongst the strips to ensure that it butts against the strips; slide the strips along the rail, if necessary.
- Repeat with the other side rail, then trim the ends of both rails flush.

3 - Preparing the side rails for the drop-leaf supports

- Mark the dowel holes on the top edges of the drop-leaf supports, locating them about 4 inches to one side of the middle.
- Offsetting the dowels in this way will allow the longer end of the

supports to rotate under the leaves.

- Install a 3/8 inch bit in your drill press and adjust the drilling depth to the dowel length about 2 inches.
- Then position the support on its side rail, clamp the assembly to the machine table with the marked point under the bit and, steadying the rail on edge with one hand, drill the hole.
- Repeat for the other side rail.

4 – How to install the supports on the rails

- Dab some glue into the holes in the rails and tap a dowel into each hole.
- Once the adhesive has cured, slip the drop-leaf supports onto the dowels.
- Use a chisel to trim the dowels flush with the tops of the supports, if necessary.

5 - Sawing the tenons on the rails

- Install a dado head rather wider than the length of the tenons 5/8 inch on your table saw.
- The tenon should be 1/8 inch shorter than the depth of the mortise you chopped in the leg.
- Screw a board as an extension to your miter gauge, then attach an auxiliary fence and raise the dado head to notch it.
- To cut the tenon cheeks, butt one of the rails against the fence and the miter gauge and feed it face down.
- Turn the rail over and repeat the cut on the other side, test-fitting the tenon in the leg mortise and raising the blades until the fit is snug.
- A loose tenon is hard to correct, so err on the side of tightness when first adjusting the height of the blades.
- Then, cut tenon cheeks at the other end and repeat for each rail.
- Then line up the leg with the rail and mark the final width of the tenon, utilizing the mortise as a guide.
- Flip the rail on edge and adjust the saw blade to the appropriate height to trim the width of the tenon.

- Again, test-fit until the tenon fits snugly in the mortise and the tops of the rail and leg are flush.
- Now prepare the drawer rail and the kicker the same way.
- Before assembling the legs and rails, Recall to prepare the rails for the wood buttons that will hold the too in place.

6 - Preparing the side rails for the cross rail

- Joined to the side rails with sliding dovetails, the cross rail adds strength to the table structure and also anchors the corner strips that hold the drawer supports.
- With the ends of the side rails aligned, mark a cutting line across the middle of the inside faces of both rails.
- Cut the dovetail sockets with a router in two steps.
- Start by installing a ¼ inch straight bit in the tool and setting the cutting depth to reach your final depth ½ inch-in two or more passes.
- Set one of the side rails inside face up on a work exterior, align the bit with your cutting line, and clamp a T square jig an edge guide with a fence fixed to it at 90 degree against the router's base plate so the jig fence butts against the edge of the rail.
- Rout the slot, then increase the cutting depth and make another pass.
- Switch to a ½ inch dovetail bit, set the depth at ½ inch, and make a last cut.
- Repeat on the other side rail, making sure to press the router base plate against the edge guide for each pass.

How to assemble the legs and rails

1 - Gluing the legs to the drawer rail

- Sand the inside faces of the legs and rails, then spread glue on the contacting exteriors amongst the kicker, drawer rail and one pair of legs.
- Fit the joints together and secure them with two bar clamps, aligning the bars with the rail and kicker.
- Utilizing wood pads to protect the stock and distribute the clamping pressure, tighten the clamps gradually until a little adhesive squeezes out of the joints.
- Repeat the procedure to assemble the remaining two less and the end rail

2 - Gluing the side rails to the legs

- Once the glue has cured, eliminate the clamps and apply adhesive to the leg mortises and side rail tenons.
- Fit the joints together and install two bar clamps to secure the assembly, aligning the bars with the side rails.
- Use wood pads as long as the tenon width to distribute clamping pressure.
- As soon as you have tightened both clamps, utilize a tape measure to confirm the assembly for square, measuring the distance amongst opposite comers; the two measurements should be equal.
- If not, install another bar clamp across the longer of the two diagonals, setting the clamp jaws on those already in place.
- Tighten the clamp a little at a time, measuring as you go until the two diagonals are equal.

3 - Making and installing the cross rail

- With the same dovetail bit in your router used to cut the sockets in the side rails, mount the tool in a table.
- Set the cutting depth to make the dovetails rather shorter than the depth of the sockets.

- Position the fence so that one-half of the cutter ventures beyond its face.
- Feed the cross rail on end across the table, pressing it against the fence.
- Turn the rail around to complete the dovetail and repeat the cuts at the other end of the rail.
- Test fit the joints and adjust the fence and make supplementary cuts, if necessary.
- Once the fit is snug, spread glue on the dovetails and in the sockets and slide the rail into place, tapping it with a mallet; utilize a wood block to protect the stock the edges of the cross rail should lie flush with those of the side rails.

How to make and install the drawer

1 - Preparing the drawer for the bottom

- Cut the front, back, and sides of the drawer to fit into the opening in the table.
- The back is narrower than the other pieces to allow the bottom to slide into place after the drawer is glued up.
- Cut the through dovetails joining the pieces, and then cut the grooves for the bottom panel in the front and side pieces on your table saw.
- Position the fence so the groove will pass through the middle of the bottommost tails on the drawer sides and set the blade height to one-half the stock thickness.
- Use a push stick to feed the pieces face down across the saw table, while pressing the stock against the fence.
- Repeat on the remaining pieces, then move the fence away from the blade by the thickness of the kerf and repeat on all three boards.
- Test fit your bottom panel typically $\frac{1}{4}$ inch plywood-in the grooves and widen them, if necessary.

2 - Assembling the drawer

- Spread glue on the contacting exteriors of the pins and tails, and then tap the four boards together utilizing a wooden mallet.
- Clamp the drawer, portioning the clamps to push the tails into the pins.
- Confirm the drawer for square.
- Once the adhesive has cured, eliminate the clamps and slide the bottom panel into place.
- Then drive a few finishing nails through the panel and into the bottom edge of the drawer back to fix it in position.

3 - Preparing the drawer for the slides

- Install a dado head on your table saw and adjust its width to

accommodate the drawer slides you will utilize typically 5/8 inch thick.

- Set the cutting height at 3/8 inch and position the rip fence to cut the groove in the middle of the drawer sides.
- Feed the drawer side-down, holding the edges flush against the fence.
- Turn the drawer over to cut the groove in the other side.

4 – Installing the corner strips

- Hold the drawer in position in the table and mark the position of the grooves in it's sides on the legs and rails.
- Cut the corner strips for each corner of the drawer, making the dadoes as wide as the grooves.
- Screw two corner strips flush against the side rail and leg at the drawer front and utilize clamps to hold the two remaining strips flush against the side rail and cross rail at the drawer back; the dadoes in all four strips should line up with the groove marks.
- Cut two drawer slides to span the gap amongst the dadoes along the side rails, less 1/16 inch for clearance.
- Notch the front end to fit around the legs, and then slip the slides into the dadoes.

5 - Installing the drawer

- Slide the drawer into position.
- It should move smoothly and sit centered and level in its opening, if not, loosen the clamps holding the back-end corner strips and adjust the height of the strips, as necessary.
- When the fit is fine, screw the back end strips to the cross rail.

6 - Attaching the false front

- Set the drawer face-up on a work exterior and drive two brads into the front, leaving the heads protruding.
- Then snip off the heads with pliers.
- Install the drawer in the table, cut the false front to size and place

it amongst the drawer rail and kicker, utilizing slips of paper as shims to hold it precisely centered and level.

- Steadying the false front with one hand, slide the drawer toward the board and firmly press the brads against it; the pointed ends of the nails will punch impressions in the wood, allowing you to reposition the false front at glue up.
- Spread adhesive on the back of the false front and clamp it to the drawer with the two brads resting in their impressions.

How to attach the top

1 - Shaping the top and leaves

- The leaves are fastened to the table top with rule joints, in which the top's rounded over edge mates with a cove cut along the edge of the leaf.
- Start by rounding over the edges of the top, utilizing a piloted round over bit in a router.
- To shape the leaves, install a piloted cove bit whose diameter and profile match the round over bit, then mount the router in a table.
- The two bits are often sold as a set.
- To support the leaves while the cut, clamp a feather board to the fence above the cutter.
- Align the fence with the bit's pilot bearing so the cutting width will equal one-half the cutter diameter.
- Set the depth of cut to reach the final depth in several passes.
- Feed one leaf into the bit, bracing its edge against the fence tight.
- After each pass, test-fit the pieces; continue cutting until the top and leaf mesh with a slight gap amongst the two.
- Repeat the procedure on the other leaf.

2 – How to attach the leaves to the top

- Join the leaves to the top by installing rule-joint hinges on the underside of the pieces.
- Set the top and leaves face down on a work exterior, then mark lines along the edges of the top in line with the start of each round-over cut, known as the fillet.
- Install three hinges for each leaf: one in the middle of the joint and one 5 inches from each end.
- With a paper shim inserted amongst the leaf and top, position a hinge leaf against the top and the other against the leaf at each hinge location so the pin is aligned with the fillet line, then outline the hinge.
- Chisel out the mortises, utilizing a wider-blade tool to cut the mortises for the hinge leaves and a narrower chisel to cut the slots

for the pins.

- Screw the hinges in place.

3 - Attaching the top to the table rails

- The top is fastened to the rails with wood buttons; screwed to the top, the buttons feature lips that fit into grooves cut into the rails, providing a secure connection while allowing for wood movement.
- Ensure the drop-leaf supports are in place on the side rails, then place the top face down on a work exterior and clamp the leg-and-rail assembly in position on top.
- Make a button for every 6 inches of rail length.
- Spacing them about 6 inches apart and leaving a 1/8 inch gap amongst the bottom of the grooves and the lipped ends of the buttons, screw the buttons in place.

Chapter 8 How to make a candle stand

Before electricity, people depended on candles to see them through the hours of darkness. These diligent workers could not allow late sunrises or early dusks to interfere with their labor.

Candle stands were light, stable, and easy to transport. The furniture makers in their communities elevated this commonplace item to its most refined expression. The elegance of the candle stand's tripod design sacrifices some strength.

Because of the angle at which they splay out, the legs are subjected to a great deal of racking stress which pulls them away from the column. The Shakers compensated for this weakness in several ways.

The most vital was attaching the legs to the column with sliding dovetails—very robust and durable joints. Some Shaker candle stands have survived 180 years and are as sturdy as the day they were made.

To give the legs added strength, a metal plate, known as a "spider," is nailed to the base of the column and legs. The design of the legs also fortifies the stand.

They are 3/8 inch denser at the top, which makes the dovetails that much robust. Also, the Shakers cut the legs so the grain runs along their length, helping them resist stress.

How to build it

- To cut the circular top of a candle stand on your band saw, utilize the shop built circle-cutting jig.
- Rout a 3/8 inch-deep dovetail channel in the middle of the jig base, then utilize a table saw to rip a thin board with a bevel along both edges to develop a bar that slides smoothly in the channel.
- Set the saw blade angle by measuring the angle of the channel edges.
- Cut out the notch on the band saw, then screw the support arms to the underside of the jig base, spacing them to hug the sides of the band saw table when the jig is in position.
- Drill two holes through the bottom of the dovetail channel in the

jig base, 1 inch and 3 inches from the unnotched end; also bore two holes through the bar.

- To prepare the work piece, mark the circumference and center of the circle on its underside.
- Then utilize the band saw to cut off the four curves of the panel to keep it from hitting the clamps that secure the jig.
- Then, make a release cut from the edge of the panel to the marked circumference, and then veer off to the edge.
- Screw the pivot bar to the center of the work piece through one of the bar's holes, leaving the screw loose enough to pivot the panel.
- Turn the work piece over and mark the point where the blade contacted the circumference while the release cut.
- Clamp the jig base to the band saw table, making sure the support arms are butted against the table's edges.
- Slide the pivot bar into the channel in the base and pivot the panel until the marked contact point touches the blade.
- Screw through one of the holes in the jig base to lock the pivot bar in place.
- Turn on the saw and pivot the work piece into the blade in a clockwise direction, feeding the piece until the cut is completed.

How to prepare the top and rail

1 - Preparing the top

- Once the top of the candle stand has been cut, shape its circumference on a router table in two steps.
- Start by installing a piloted $\frac{1}{2}$ inch radius bit in a router and mounting the tool in a table.
- Align the fence with the bit's pilot bearing and clamp a feather board to the fence to support the top while the cut.
- Holding the top face-up and flat on the table, press the edge against the fence and rotate the stock into the bit.
- Continue pivoting the top until the entire circumference is fashioned, then switch to a piloted $\frac{1}{4}$ inch radius bit, turn the work piece over, and repeat to shape its top side.

2 – How to make the rail

- Cut the rail that will connect the column to the table top, then bore a mortise in the center of the rail to accept the tenon you will turn at the top of the column; a 1 inch diameter hole is typical.
- Bevel the ends and edges of the rail on your table saw.
- Attach an auxiliary fence and position the fence to the left of the blade for a $\frac{1}{4}$ inch cutting width.
- Raise the blade to its maximum setting, adjust the angle to about 75 degree, and clamp a guide block to the rail to ride along the top of the fence.
- Mark a line across the face of the rail rather above the height of the blade as a reminder to keep your hands well above the blade.
- Feed the rail into the blade on end, keeping it flush against the fence and pushing it forward with the guide block.
- Repeat the cut at the other end of the rail.
- Then bevel the long edges by adjusting the blade angle to 45 degree.
- Sand the rail smooth.

How to make the column

1 - Turning the column

- Mount a 3 ½ inch-square blank on your lathe and turn it with a roughing gouge followed by a spindle gouge, leaving a lip and enough stock near the bottom for the leg sockets.
- To help you develop the appropriate shape, fashion yourself a template, as you would to turn a drop-leaf table leg.
- Use a parting tool to turn the rail tenon at the top of the column, periodically checking its diameter with outside calipers tight.
- Smooth the column with progressively finer grits of sandpaper.

2 – How to rout the dovetail sockets

- Unplug the lathe and cut the sockets, utilizing a router and a shop-made jig consisting of a ¾ inch plywood box clamped to the lathe bed.
- Make the inside width of the box as wide as the router base plate, attaching the runners so the router bit will cut the sockets with its base plate sitting on them.
- Then, mark the three socket locations on the column, spacing them 120 degree apart.
- Also mark the top ends of the sockets, 3 7/16 inches from the bottom of the column.
- Transfer the socket marks to the lathe faceplate, then rotate the column by hand until one of the marks on the faceplate is vertical and immobilize the drive shaft with a hand screw.
- Cut each socket in two steps, starting with a ¼ inch straight bit.
- Adjust the cutting depth to about ½ inch and, aligning the bit with the socket end mark, butt a stop block against the router base plate.
- Screw the block to the jig.
- Holding the router in both hands, feed the bit into the column at the bottom and guide the tool along the runners until the base plate contacts the stop block.
- Repeat with a ¼ inch dovetail bit.
- To cut the two remaining sockets, rotate the column until the socket mark for each cut is vertical.

How to make the legs

1 – How to cut the dovetail cheeks

- Fashion a template for the legs.
- The grain should follow the slope of the leg, the top and bottom ends must be perpendicular, and the spread of the less must be less than the diameter of the top.
- Once the template is complete, saw along the top end of the leg on the band saw.
- Then, cut the dovetails in the legs in two steps, cutting the cheeks on your table saw and the shoulders by hand.
- Adjust the table saw's blade angle to match that of the sockets you cut in the column and set the cutting height to rather less than the depth of the sockets.
- Outline the dovetails on the edge of one leg blank and, holding the blank on end on the saw table, align a cutting mark with the blade.
- Butt the rip fence against the stock and lock it in place.
- Clamp a shimmed feather board to the table and a guide block to the blank.
- Make a pass to cut one cheek, then rotate the blank and feed the opposite face along the fence to saw the other.
- Confirm the resulting dovetail against a socket in the column.
- If necessary, adjust the cutting width or blade angle or height and make another set of passes.
- Repeat for the remaining dovetails

2 – How to cut the angled shoulders

- The shoulders of the leg dovetails must be cut at an angle so they lie snugly against the column.
- Once the dovetail cheeks are all cut, clamp a blank to a work exterior with the cheeks extending off the table.
- Then utilize a backsaw to cut the shoulders at a rather sharper angle than the curvature of the column.
- Test fit the dovetail in its socket and trim the socket, if necessary, until you get a suitable fit.

- Repeat for the remaining dovetails

3 – How to shape the legs

- Cut out the legs of the candle stand on your band saw, then smooth their exteriors utilizing a sanding block or a spindle sander.

4 – How to trim the dovetail

- Trim off the top $\frac{3}{4}$ inch of each dovetail on the legs.
- This will hide the tops of the dovetails from view when they are pushed all the way into their sockets.
- Clamp the leg upright in your bench vise and mark a line on the dovetail $\frac{3}{4}$ inch from the top end.
- Then hold a $\frac{1}{4}$ inch chisel vertically to score the dovetail on your marked line, cutting to the shoulder.
- Then, holding the chisel bevel up and parallel to the dovetail shoulders, push the blade along the exterior to pare away the wood in thin shavings.
- Periodically test-fit the leg against the column until the shoulders rest flush against the exterior.

5 – How to taper the legs

- To give the legs an elegant appearance without sacrificing strength, taper them with a bench plane from a thickness of 1 inch at the top to $\frac{5}{8}$ inch at the bottom.
- Mark taper lines along the inside edges of each leg as a planing guide.
- Then secure the leg face up on your bench, utilizing a notched wood block to fix the bottom end in place.
- To avoid damaging your plane blade, ensure that the bench dogs and the wood block are below the level of the top taper line.
- Starting near the top of the leg, feed the plane along the exterior, increasing the downward pressure as you approach the bottom.
- Continue until you cut to the taper line, then turn the leg over on

the bench and repeat the procedure.

How to assemble the table

1 – How to attach the rail to the column

- Start by drilling six countersunk screw holes through the rail; it will be less cumbersome to prepare the rail for the top before joining the rail and column.
- Locate one hole in each corner of the flat face of the rail's underside and one on each side of the mortise.
- Then set the top face down on a work exterior and center the rail on top, making sure the grain of the two pieces is perpendicular.
- Mark the curves of the rail on the top with a pencil and the screw holes with an awl.
- To prepare the column for the rail, utilize a backsaw to slice a kerf or a wedge in the center of the tenon to a depth of about three quarters the length of the tenon.
- Cut the kerf at a right angle to one of the dovetail sockets so the rail will be parallel to one of the legs.
- Cut the wedge from hardwood about 1 inch long and 1/8 inch thick at the base, tapering it to a point.
- To fasten the rail to the column, spread glue on their contacting exteriors and fit the pieces together with the kerf in the column tenon perpendicular to the grain of the rail.
- Then, holding the column upright on a work exterior, apply glue in the kerf and on the wedge and hammer it in place with a wooden mallet.
- Trim the wedge flush with the end of the tenon.

2 – How to fasten the legs to the column

- Spread glue equally on the dovetails and in the sockets.
- Then, setting the rail flat on a work exterior, slide the legs into place and tap them into final position with a wooden mallet.
- To strengthen the assembly, add a three-armed spider cut from sheet metal.

3 – How to screw the rail to the top

- To complete the table, set the top upside down on your work exterior and drill pilot holes into it at the points you marked in step 1.
- Position the rail assembly on the top, aligning its curves with the marks on the exterior and its screw holes with those in the top.
- Screw the rail in place.

Chapter 9 How to make a step stool

In their quest for order and efficiency, the Shakers built chests of drawers and cabinets that made good use of obtainable space, often stretching from floor to ceiling.

Step stool to enable household members to gain access to the uppermost shelves. Depending on individual needs, the stool were made in two-, three-, and four step types.

The taller stool often featured steadying rods screwed to the side to provide a hand hold. While these stool appeal to the modern eye, usefulness was the Shaker builder's sole concern.

Through dovetails were chosen to attach the treads to the sides because the interlocking joints gave the stool strength and stability. The stool were traditionally cut from cherry except for the $\frac{3}{4}$ inch thick crosspieces.

Once you have cut your stock for the sides of the stool, utilize a pencil to mark the top, bottom, and front and back edges of each piece. This will help you avoid any confusion when you come to cut the pins at the sides top ends.

How to cut the dovetails

1 – How to notch the sides for the crosspieces

- The sides are made from two boards glued together after the notches and the pins of the dovetail joint are cut in them.
- Outline the notches on the edges of each side piece, and then cut them on your table saw.
- Install a dado head on the saw and set the cutting height to the notch width.
- Screw a board to the miter gauge as an extension.
- Make several passes to cut each notch, feeding the stock up on edge with the miter gauge.
- Use the rip fence as a guide for cutting up to the notch end line.

2 – How to lay out the pins

- Set cutting gauge to the stock thickness and scribe a line around the top end of each side piece to mark the shoulder line of the tails.
- Then, utilize a dovetail square to outline the pins on the same end; the wide part of the pins should be on the inside face of the stock.
- Start with a half-pin at each edge and add equally spaced pins in amongst.
- To complete the marking, secure the pins in the vise and utilize a try square and pencil to extend the lines on the board end to the shoulder lines.
- Mark the waste sections with X-s as you go.

3 – How to cut pins

- Leave the piece in the vise and utilize a dovetail saw to cut along the edges of the pins, working from one side of the board to the other.
- For each cut, align the saw blade just to the waste side of the cutting line.
- Use smooth, even strokes, allowing the saw to cut on the push stroke.
- Continue sawing right to the shoulder line, making sure that the blade is perpendicular to the line.

4 - Chiseling out the waste

- Set the side piece inside face up on a work exterior and clamp on a guide block, aligning its edge with the shoulder line.
- Utilizing a chisel no wider than the narrow side of the waste section, butt the flat side of the blade against the guide block.
- Hold the end of the chisel square to the face of the piece and strike it with a wooden mallet, scoring a line about 1/8 inch deep.
- Then turn the chisel toward the end of the panel about 1/8 inch below the exterior of the wood and shave off a thin layer of waste.
- Continue shaving away the waste in this fashion until you are about halfway through the thickness of the piece, then move on to the Then section.
- When you have eliminated all the waste from this side, turn the

piece over, and work from the other side until the pins are completely exposed.

5 – How to lay out the tails

- Set a tread bottom-face up on a work exterior.
- Hold one of the side pieces pins down with its inside face aligned with the shoulder line of the tread.
- Use a pencil to outline the tails at each end of the tread, and then extend the lines on the board utilizing a try square.
- Mark the waste with X-s and repeat the procedure with the remaining tread.

6 – How to cut the tails and removing waste

- Use a dovetail saw to cut the tails the same way you cut the pins step 2.
- Angling the board, rather than the saw, makes for easier cutting.
- Saw smoothly and equally, stopping just short of the shoulder line.
- You can also cut the tails on your band saw.
- Eliminate the waste with a chisel as in step 4.

7 - Testing the fit of the joints

- Before gluing up the stool, assemble it to confirm the fit of all the joints.
- Stand one of the side pieces on end, and then align a tread with it.
- Press the joint together by hand as far as it will go, and then utilize a mallet to tap the tread the rest of the way into place.
- The boards should fit snugly, requiring just a light tapping; avoid utilizing excessive force.
- If any joint is clearly too tight, mark the spot where it binds, then disassemble the boards and utilize a chisel to pare away a little more wood.
- Test fit the joint again and adjust it further, as necessary.

How to glue up the step stool

1 – How to glue up the sides

- Set a pair of bar clamps on a work exterior and lay two boards that make up a complete side piece on them.
- Spread glue on the contacting edges of the boards, align their bottom ends, and tighten the clamps until there are no gaps amongst the boards and a thin bead of adhesive squeezes out of the joint.
- Glue up the other side piece the same way.

2 - Relieving the side pieces

- By cutting a semicircle out of the side pieces, leaving two legs on each side, the stool will be more stable on uneven exteriors.
- Adjust a compass to a radius of 3 ½ inches and mark a semicircle on one of the side pieces, placing the compass point at the bottom end of the sides midway amongst the edges.
- Cut the semicircle on your band saw, feeding the stock across the table with both hands.
- Then make the same cut on the other side piece.
- You can then smooth away the marks left by the saw blade on a spindle sander.

3 - Installing the treads

- Spread an even layer of glue on the contacting exteriors amongst the pins and tails, and then assemble the stool, setting the treads on the side pieces.
- Secure the joints with bar clamps, aligning the bars with the side pieces and utilizing wood pads as long as the tread width to distribute the clamping pressure.

4 - Attaching the crosspieces

- Set the step stool on its back edge and apply glue to the contacting

exteriors amongst the crosspieces and the sides and treads.

- Place the crosspieces in their notches and clamp them securely in place.
- Near each end of the crosspieces, drill a counter bored hole for a wood screw through the crosspiece and into the front edge of the side piece.
- Drive a screw into each hole.
- For a perfect match, utilize a plug cutter on your drill press to cut plugs from the waste wood left by relieving the side pieces Step 2.
- Spread glue on the plugs and tap them into their holes, ensuring that the grain direction of each runs in the same direction as the crosspiece.
- Use a chisel to trim the plugs flush with the exterior, then sand them smooth.

Chapter 10 How to make a wall clock

First we will begin by building a case.

1 - Rabbeting the side panels

- Prepare the case pieces for assembly by rabbeting the ends of the side panels on your table saw.
- Install a dado head on the saw and adjust its width to 9/16 inch.
- Set the cutting height at 5/16 inch.
- Screw a wooden auxiliary fence to the rip fence and notch it with the dado head.
- To help you feed the long stock across the saw table and to minimize tear out, screw a board as an extension to the miter gauge.
- Then, butting one side panel against the fence and the extension, feed it along with the miter gauge to cut the first rabbet.
- Repeat at the other end of the board and at both ends of the second side panel.
- To prepare the side panels for the backboard, cut a rabbet along the back edge of each board.

2 - Preparing the side panels for the divider

- Outline the dado on the front edge of each side panel that will accept the divider.
- The length of the dado should be about one-half the width of the divider.
- Install a straight bit the same diameter as the dado width in a router, butt one side panel on a work exterior against a backup board, and align the bit over the outline.
- Butt a board as an edge guide against the router base plate and clamp the setup in place.
- With the base plate flush against the edge guide, plunge the bit into the backup board and guide it into the side panel, stopping the cut at your end line.
- Rout the dado in the second side panel, and then square both

dadoes with a chisel.

3 - Preparing the divider for installation

- Leaving the auxiliary fence and miter gauge extension on your table saw, notch the ends of the divider to fit into the dadoes you cut in the side panels.
- Position the fence to cut a 5/16 inch-wide notch and set the cutting height of the dado head to 7/8 inch.
- Holding the divider on edge and flush against the fence and extension, feed the miter gauge into the blades.
- Turn the board around and notch the other end.

4 - Rounding over the divider

- Round over the front edge of the divider on a router table.
- Install a piloted 1/4 inch round-over bit in a router, mount the tool in a table, and align the fence with the bit's pilot bearing.
- To support the divider, utilize three feather boards, clamping two to the fence, one on each side of the bit, and one to the table.
- Brace this second feather board with a support board secured to the table.
- Now utilize a push stick to feed the divider across the table.
- Make two passes to round over each face of the stock, starting with a shallow cut and raising the bit rather for the second pass.

5 - Cutting the backboard

- Use a piece of solid wood for the backboard a Shaker builder would typically have used pine.
- To mark out the arch at the top of the backboard, first mark a center line near the top end of the stock and utilize a compass to outline a circle with a radius of 2 1/4 inches in the middle of the stock, centered 2 1/4 inches from the top end.
- Then, mark a straight line across the stock 3 3/8 inches from the top end.
- Draw two perpendicular lines to accommodate the notches in the

top panel.

- Use your band saw to cut out the arch.
- Set the stock on the saw table and feed the piece with both hands, making the straight cuts first and then sawing the semicircle.

6 - Drilling the peg hole in the backboard

- To ensure the clock will hang level, the hole must be centered amongst the edges of the backboard.
- Mark a drilling point on your centerline 1 7/8 inches from the top of the arch, then bore the hole on your drill press.
- Install a 1/2 inch brad-point bit in the machine and clamp a backboard in place, and drill the hole.

7 – Preparing the top panel and top with trim piece for the backboard

- You will need to cut a notch in the back edge of the top panel and top trim piece of the clock case to accommodate the backboard.
- Outline the notch in the middle of the edge of each piece.
- Leave the dado head and miter gauge extension on your table saw, but move the fence out of the way.
- To cut the notches, align the dado head with one end of the outline, raise the blades to the thickness of the backboard, and utilize the miter gauge to feed the panel into the cut.
- Then, slide the work piece along the extension by the width of the kerf and make another pass, continuing until you reach the other end of the outline.
- Use the same setup to prepare the top trim piece for the backboard.

8 – How to assemble the case

- Smooth the case pieces and the backboard, utilizing progressively finer sandpaper, finishing with 220-grit.
- Assemble the case in two steps, starting with the four panels and the divider.
- Spread glue on all the contacting exteriors of the pieces and clamp the joints securely.

- Confirm the curves for square by measuring the distance amongst diagonally opposite curves of the case.
- The two measurements should be the same; if not, adjust the clamping pressure until they are.
- Once the glue has cured, eliminate the clamps, set the assembly face down on a work exterior, and fit the backboard in position.
- It is secured with nails; do not utilize any glue, since the board must be free to move as the wood swells and contracts with humidity changes.
- Bore pilot holes for finishing nails through the backboard and into the rabbets along the back edges of the case panels.
- Space the holes about 4 inches apart, and then drive the nails in place.

How to make the doors

1 - Cutting the tenons in the rails

- Use your table saw to cut the open mortise and tenons that join the rails and stiles of the doors.
- Saw the pieces to size, then install a commercial tenoning jig on the saw table.
- Clamp one of the rails end-up to the jig, utilizing a wood pad to protect the stock.
- Make the cutting height equal to the stock width and position the jig so the outside faces of the blade and the work piece are aligned.
- Push the jig forward to feed the rail into the blade, and then turn the stock around and repeat the cut on the other edge.
- Move the jig toward the blade rather so the thickness of the tenon will be equal to about one-third the stock thickness and make two more passes.
- Repeat the procedure to cut tenon cheeks on the other end of the rail and at both ends of the remaining rails.

2 - Sawing the mortises

- Clamp one of the door stiles end-up to the jig, position the jig to center the edge of the work piece with the blade, and feed the stock into the cut.
- Then move the jig very rather away from the blade to enlarge the mortise.
- Make another pass, turn the stile around in the jig, and feed it into the blade again.
- Then, test fit one of the rail tenons in the mortise.
- If the fit is too tight, move the jig away from the blade rather and make two more passes, continuing until the tenon fits snugly in the mortise.
- Use the same procedure to cut the mortises at the other end of the stile and at both ends of the remaining stiles.
- You can also utilize a shop made jig to cut this joint.

3 - Gluing up the rails and stiles

- Dry assemble the two door frames to confirm the fit of the joints.
- If they are too tight, utilize a chisel to pare away excess wood; if any of the tenons extends beyond the outside edges of the stiles, sand it flush.
- Then spread glue on the contacting exteriors of the rail tenons and stile mortises, and assemble the frames.
- Use three clamps to secure each assembly, aligning one with each rail and centering a third amongst the stiles; protect the stock with wood pads.
- Tighten the clamps a little at a time until a thin glue bead squeezes out of the joints, checking the frame for square as you go.

4 – Preparing the door frames for glass panels

- Each door will have a glass panel that sits in rabbets cut along the inside edges of the frame; the glass is held in place by strips of molding.
- Once the glue has cured, eliminate the clamps and cut the rabbets on a router table.
- Install a ½ inch top-piloted straight bit in a router and mount the tool in a table.
- Adjust the bit height to the combined thickness of the glass and molding you will be utilizing.
- Eliminate the fence and set a door frame on the table.
- Turn on the tool and press the inside edge of the frame against the bit near one corner, then rotate the stock clockwise to cut the rabbets along the rails and stiles.
- Keep the frame flat on the table as you feed it into the bit.
- Square the curves of the rabbets with a mallet and a wood chisel.
- Repeat the procedure for the other door.

5 - Mounting hinges on the doors

- The doors are hung on the clock case with butt hinges: the hinge leaves are concealed in recesses cut into the inside faces of the

doors and the front edges of the case.

- Position each door in turn on the case and outline the hinge leaves on the doors and the case.
- To cut the recesses in the doors, clamp the frame to a work exterior inside-face up.
- Cut each recess with a chisel in two steps.
- Start by holding the chisel vertically on your outline with the bevel facing the waste and tap the handle with a mallet, moving the chisel along to score the entire outline.
- Then pare away the waste in thin layers, holding the chisel horizontally, bevel-side up.
- Test fit a hinge leaf in the recess periodically, stopping when the recess is about 1/64 inch deeper than the thickness of the leaf.
- With the hinge leaf in position, mark the screw holes in the recess, bore a pilot hole at each mark, and screw the hinge leaf to the door.
- Use the same procedure to cut the recesses in the front edges of the case.

6 - Making the glass-stop molding

- Cut the molding that will secure the glass in the doors from a single 5/8 inch thick board.
- Start by rounding over both edges of the piece as you did for the divider, and then rip the molding from the board on your table saw, feeding the stock with a push stick.
- Saw the molding to fit into the rabbets in the doors, making 45 degree miter cuts at the ends of each piece.
- Cut and fit one piece at a time, making sure to align the miter cuts with the curves of the rabbets.

7 - Securing the glass

- Have glass panels prepared for the door, cutting them 1/8 inch shorter and narrower than their openings.
- This will leave a 1/16 inch gap around the glass to allow for wood movement.

- Apply your finish to the door frames, let it dry, then set the door frames and glass on a work exterior and place the molding in position.
- Bore pilot holes for finishing nails through the molding and into the frame every 2 inches, then drive the nails utilizing a brad driver.
- To utilize the driver, insert a nail into a pilot hole, then position the jaws and tighten the locking nut.
- Holding the frame steady, squeeze the jaws to set the nail.
- Use a piece of cardboard to protect the glass.

Final assembly

1 - Gluing on the trim pieces

- Cut the top and bottom trim pieces to size, then round over one face of their side and front edges on a router table utilizing a 9 ½ inch round over bit.
- To install the pieces, set the clock case on its back on a work exterior and spread glue on the contacting exteriors of the trim pieces and the top and bottom panels.
- Position the trim pieces so their back edges are flush with the back of the case and secure them with bar clamp spaced every 4 to 6 inches.
- Tighten the clamps until a little glue squeezes out of the joints.

2 - Preparing the case for the dial and clock mechanism

- The dial and clock mechanism are attached to a thin plywood backing board, which in turn is screwed to cleats glued to the inside of the case.
- Cut two cleats to fit along the inside face of the case side panels amongst the top panel and the divider.
- Cut a third one to run along the inside face of the top panel amongst the side panels.
- To help you mark the positions of the cleats, test fit the clock in the case, recalling to allow for the doors.
- Once the cleat position is certain, spread glue on the contacting exteriors amongst the cleats and the case, and clamp the cleats in place.

3 - Assembling the clock mechanism

- Assemble the clock mechanism following the manufacturer's directions.
- Position the dial on the backing board provided and outline the shaft hole on the board.
- Eliminate the dial and bore the shaft hole through the backing

board on your drill press.

- Fix the dial to the backing board with epoxy, making sure the dial is centered amongst the board's edges.
- To attach the clock movement, insert the shaft through the shaft hole and the dial, then tighten the nut on the shaft by hand.
- If the shaft protrudes too far from the dial, loosen the nut, eliminate the movement and slip one or more washers amongst the movement and the backing board.
- A number of washers are supplied with most models.

4 - Securing the clock assembly to the case

- Position the backing board in the clock case and drill pilot holes for $\frac{3}{4}$ inch No. 6 wood screws through the board and into the cleats.
- Bore a hole at each corner, and then drive in the screws.

5 – How to hang the doors

- Set the clock on it's back and position the top door on the case.
- With the hinge pin centered amongst the edges of the door and case, mark the hinge leaf screw holes in the case.
- Bore the holes and drive the screws, then repeat the procedure for the bottom door.
- If either door binds against the divider, try sanding the binding rail.
- Now apply a finish to the clock case.

6 - Installing the pendulum

- Most pendulum weights have a brass finish that is simply scratched.
- The weight is typically protected by a plastic covering.
- Do not eliminate the covering until the pendulum has been mounted.
- Slide the pendulum rod under the clock face so it's top end catches on the hook under the movement.

- The clock can now be hung on a wall from a hook or a pegboard.

Chapter 11 How to make a pie safe

Pie safes were once common in American kitchens. All appropriateness and goods in Shaker communities were owned collectively, to be used as required. Since belongings were not reviewed private, latches and locks on the doors of a pie safe would have been superfluous.

Doors supported straightforward wooden knobs and mating rabbets cut along the inside faces of their stiles so they would close flush and firmly together. The most clever feature of the safe lies in the design of the tin door panels.

The cabinets had to keep rodents and insects from getting inside while allowing enough air to circulate to prevent the food from becoming stale. With the usage of tin door panels, Shaker furniture makers solved both issues at once.

The small holes in the panels permitted the passage of air. And, by punching the holes from the inside out, they created sharp edges on the outside that discouraged the intrusion of vermin.

For maximum ventilation, Shaker pie safes traditionally featured tin panels on the sides as well as in the doors. One of the charming elements of these pieces is the hole pattern.

The designs were every so often abstract and pineapple fashioned or floral. But again, these particulars were not mostly intended to be ornamental or flamboyant.

The panels had to be perforated, so the Shakers chose to punch the holes symmetrically to avoid an unnecessarily ornate or otherwise distracting appearance. Pie safes were traditionally made from cherry, while communities where hardwoods were scarce often resorted to pine.

This chapter provides detailed step-by-step instructions for building a Shaker-inspired safe, beginning with cutting the rails, stiles and panels for the cabinet and continuing through gluing up the case, making and installing the shelves, and assembling the doors.

While rooted in the Shaker tradition, a pie safe would be a perfect addition to any modern, country-style kitchen.

The pie safe featured in this chapter comprises four frames joined at the

curves. Each frame is made with rails and stiles connected with mortise-and-tenons. The side frames are grooved to house floating wood panels.

The back frame is divided in half by a mullion and is rabbeted around the inside edges to accommodate fixed back panels. The front frame is made the same way as the sides, with two hinges holding each door to its stiles.

To assemble the safe, the side frames are built first and then glued together with the front and back rails. The top and bottom are solid panels of edge-glued boards.

The top is held in place by wood buttons and the bottom is fastened to ledger strips. The solid wood shelves sit on support boards that are held by corner strips. The inside edges of the front frame are rabbeted to accommodate cockbeading.

How to make the casework frame

- The first step in building a pie safe is to cut and prepare the frame stiles, and join them in pairs to form the curves of the cabinet.
- All of the mortises are cut in the stiles, and then the tenons are cut at the ends of the rails.
- The best technique for cutting the blind tenons is by hand with a backsaw and a miter box.
- Then, the frames are dry-assembled and grooves are routed along their inside edges for the floating wood panels.
- Lastly, the top rails are grooved on the table saw to accommodate the wood buttons that will secure the top.

How to prepare the stiles

1 - Tapering the stiles

- Cut the frame stiles to size, then taper their bottom ends.
- The tapers will give the bottom of the stiles an elegant, leg like appearance.
- Clamp one of the stiles face up on a work exterior and make one cutting mark on its bottom end 1 ½ inches from the inside edge and another mark on the edge 5 inches up from the bottom.
- Join the two marks with a line, and then utilize a rip saw to cut the taper along the line.
- Use the tapered stile as a template to mark cutting lines on the remaining stiles, and then taper them the same way.
- Sand all the cut edges smooth.

2 - Gluing up the stiles

- Glue the stiles together in pairs to form the corner of the pie safe.
- Recall that the four wider stiles will be used on the front and back of the safe, while the narrower stiles will fit on the sides; this way, the corner joint will just be visible from the sides.
- Spread some glue on the contacting exteriors of each pair of stiles: the outside edges of the side stiles and the inside faces of the front and back stiles.
- With the side stile face down on a work exterior, secure the joint, spacing the clamps about 12 inches apart; protect the stock and distribute the clamping pressure with wood pads.
- To secure the joint where the stile has been tapered, utilize a cut-off from the taper cuts you made in step 1 to square the clamp on the stock.

3 - Cutting the mortises in the stiles

- Each stile needs a mortise at the top and bottom to accommodate a rail tenon; you also have to cut three more mortises in each of the side stiles for the median rail tenons.

- You can utilize a power tool such as a hollow chisel mortiser to make the cut, or chisel them out by hand.
- Outline the mortises on the edges of the stiles, and then clamp one of the glued-up stiles to a work exterior.
- Starting at one end of the outline, hold a mortise chisel square to the edge of the stile and strike it with a wooden mallet.
- Use a chisel the same width as the mortise and be sure the beveled side of the blade is facing the waste.
- Make another cut $\frac{1}{4}$ inches from the first.
- Continue until you reach the other end of the outline, then lever out the waste to a depth of about $\frac{7}{8}$ inch.
- Repeat to cut the remaining mortises, and then smooth the bottom of the mortises with a lock-mortise chisel.

How to prepare the rails

1 - Cutting the tenon cheeks

- Outline the tenons at both ends of the rails, marking a shoulder line all around the ends so the length of the tenons will be rather less than the depth of the mortises you cut in the stiles.
- Secure one of the rails upright in a vise and cut along the lines on the end of the board with a backsaw until you reach the shoulder line.
- Repeat for the tenon at the other end of the rail and at both ends of the remaining rails.

2 - Sawing the tenon shoulders

- To eliminate the waste from the tenon cheeks, secure a miter box in the vise, then set the rail on the base of the box, aligning the shoulder line with the 90 degree slot.
- Tighten the clamps in the box to hold the rail in position.
- Slip the backsaw blade into the slot and cut along the shoulder line on the face of the board, stopping when you reach the kerf you cut in step 1.
- Turn over the stock and repeat the operation on the other side.
- To cut away the waste on the edges of the tenon, secure the rail upright in the vise and saw to the shoulder line on both edges of the rail.
- Lastly, clamp the rail edge up and cut through the shoulder line on both edges of the rail.

3 - Preparing the top rails for wood buttons

- Once all the tenons are completed, you will need to cut a groove along the top frame rails of the safe to accommodate the wood buttons that will secure the cabinet top in place.
- Install a dado head on your table saw, adjust it's width to $\frac{1}{4}$ inch, and set the cutting height at about $\frac{7}{8}$ inch.
- Position the rip fence about $\frac{3}{4}$ inch from the blades and install two

feather boards to support the rails, clamping one to the fence above the dado head and another to the table.

- Brace the second feather board with a support board.
- Feed the rails into the dado head inside-face down and with the top edge pressed against the fence.
- Finish each pass with a push stick.
- Cut the panel grooves along the inside edges of the side frames with a router and a piloted three-wing slotting cutter.
- Dry-assemble each side frame and clamp one of them face down on a work exterior.
- Adjust the router's cutting depth to center the groove on the edges of the stock.
- With a firm grip on the router, turn on the tool and lower the base plate onto the exterior.
- Guide the bit into the stock near one corner of the frame.
- Once the pilot bearing butts against the edge of the stock, continue the cut in a clockwise direction.
- Repeat the procedure for the other panel openings, repositioning the clamps as necessary.

How to raise the panels

- Raised panels, with their distinctive beveled edges, evolved as a practical solution to two common issues faced by Shaker cabinetmakers: how to fit thick panels into frames made of thinner stock and how to compensate for wood movement.
- Beveling the panels allowed them to fit in the grooves in the inside edges of the frames.
- No adhesive was used, so the panels could swell and shrink with changes in humidity.
- Cut the panels $\frac{1}{2}$ inch longer and wider than the openings in the frames.
- There are several ways of raising panels.
- Shaker builders likely did the job by hand, utilizing panel-raising planes.
- A more common approach involves beveling the edges of panels on a router table or table saw.
- Most furniture makers other than the Shakers have installed the panels with the raised, central portion facing outward, adding visual interest to their pieces.
- While Shakers in the Western communities, where German influence admitted some decoration, might have done the same, the Shaker creed frowned on extraneous ornamentation.
- As an outcome, Shaker pie safes were often built with the flat side of the panels facing out, while the eye-catching, raised faces are hidden from view on the inside.

How to make a raised panel with a router

- Install a panel-raising bit in your router and mount the tool in a table.
- Position the fence in line with the bit's pilot bearing and set the cutting depth at 1/8 inch so that you can reach your final depth in two or more passes.
- Lower the guard over the bit and turn on the router.
- To minimize tear out, cut the end grain of the panel first, beveling the top and bottom before the sides.
- Keep the panel flat on the table inside face down and flush against the fence as you feed it across the bit.
- Repeat the cut at the other end and along both sides.
- Turn off the router and test-fit one end in a frame groove.
- If the panel lies less than ¼ inch deep in the groove, increase the cutting depth rather and make another pass all around.
- Continue in this fashion until the panel fits appropriately.

How to make raised panels on a table saw

1 - Beveling the ends

- To determine the blade angle for raising the panels, draw a $\frac{1}{4}$ inch square at the bottom corner of one piece, then mark a line from the inside face of the panel through the inside corner of the square to a point on the bottom edge $\frac{1}{8}$ inch from the outside face.
- Install a 6 inch wide auxiliary wood fence, hold the panel against the fence and adjust the blade angle until it aligns with the marked line.
- Then, adjust the blade height until the outside tip of one tooth extends beyond the inside face of the panel, and then clamp a guide block to the panel to ride along the top of the fence.
- Feed the panel into the blade, keeping it flush against the fence while pushing it forward with the guide block.
- Test fit the cut end in a frame groove.
- If less than $\frac{1}{4}$ inch of the panel enters the groove, move the fence a little closer to the blade and make another pass.
- Repeat the cut at the other end of the panel.

2 - Beveling the sides

- Beveling the sides after you have beveled the end grain helps minimize tear out.
- Set the panel on edge and feed it into the blade, keeping the back flush against the fence.
- Turn the panel over to cut the remaining edge.
- To raise a panel on the table saw without adjusting the angle of the blade, utilize the shop built jig.
- Screw the lip along the bottom edge of the angled fence; ensure that you position the screws where they will not interfere with the blade.
- Prop the angled fence against the auxiliary fence at the same angle as the cutting line marked on a panel, utilizing a sliding bevel to transfer the angle.
- Cut triangular supports so fit precisely amongst the two fences,

and then fix them in place with screws.

- Countersink the fasteners so the panel will slide smoothly along the angled fence.
- To utilize the jig, position it on the saw table with the joint amongst the lip and the angled fence about 1/8 inch from the blade.
- Butt the table saw's rip fence against the jig's auxiliary fence and screw the two together.
- Turn on the saw and crank up the blade slowly to cut a kerf through the lip.
- Then, seat the panel in the jig and adjust the height of the blade until a single tooth protrudes beyond the front of the panel.
- Make a test cut in a scrap board the same thickness as the panel and then confirm its fit in the groove; adjust the position of the fence or blade, if necessary.
- Then cut the panel, beveling the ends before sawing the sides.

How to assemble the safe

- Once all the floating panels are ready, it is time to glue the frames together.
- Start by fitting the panels into their frames, then glue up the rails and stiles, forming the sides of the cabinet.
- The Then step involves installing the back panel on the frame.
- The pie safe featured in this chapter embraces two of the few decorative touches found in Shaker furniture: crown molding and cockbeading around the inside edges of the door openings in the front frame.
- The molding provides a smooth visual transition from the front and sides to the top of the safe.
- While molding might appear to be an extraneous embellishment, the restrained, unadorned design is excusively in keeping with the Shaker ideals of straightforwardness and harmony.

How to assemble the safe panels

1 - Fitting the panels into their frames

- Test-assemble the side frames.
- If a joint is too tight, disassemble the pieces and utilize a chisel to pare away some wood.
- Once you are satisfied with the fit, sand any exteriors that will be hard to reach when the frame has been glued up, and spread adhesive on all the contacting exteriors of the rails and stiles.
- Do not apply any glue in the panel grooves; the panels must be free to move within the frame.
- Set one of the stile pairs on a work exterior, fit the rail tenons into their mortises, and then slip the frames into their grooves, tapping them into position with a mallet, if necessary.
- Fit the opposite stile pair on the rails and clamp the frame.

2 - Clamping the side frames

- Set the frame inside-face down on a work exterior and secure the mortise-and tenon joints with bar clamps.
- Aligning the bars with the rails, tighten the clamps until a glue bead squeezes out of the joints.
- Protect the stiles with wood pads.
- Use a try square to ensure that the frame remain square as you tighten the clamps.
- Once the adhesive has cured, eliminate the clamps and then sand all the wood smooth.

How to glue up the safe

1 - Gluing the front and back to the sides

- Prepare the rails of the front and back of the pre safe as you would for the sides and also cut a mullion for the back frame.
- Cut tenons at the ends of the mullion and rout or chisel out matching mortises in the edges of the back frame rail.
- Then glue the pieces together, utilizing a long bar clamp to secure the joints.
- Set the side frames inside-face up on your shop floor and spread some glue on all the contacting exteriors amongst the side frames and the front and back.
- Fit the back frame tenons into their mortises in one of the sides, and then install the front frame the same way.
- Lastly, set the remaining side frame on top.

2 - Clamping the safe

- Cautiously set the cabinet upright, working with a helper, if necessary.
- Use four more bar clamps to secure the sides to the front and back, aligning two clamps with the top rails of the front and back and the remaining two with the bottom rails.
- Be sure to protect the stock with wood pads.
- As soon as you have tightened all the clamps, utilize a tape measure to confirm the safe for square, measuring the distance amongst opposite curves; the two measurements should be equal.
- If not, install another bar clamp across the longer of the two diagonals, setting the clamp jaws on those already in place.
- Tighten the clamp a little at a time, measuring as you go until the two diagonals are equal.

3 - Installing the back panels

- Set the safe down with its back facing up, then install a piloted 3/8 inch rabbeting bit in a router and adjust the cutting depth to 1/16

inch more than the thickness of the back panels you are utilizing.

- Rout the rabbets around the inside edges of the back panel openings, keeping the bit's pilot bearing pressed against the stock throughout the cut, and then square the curves with a chisel.
- Cut two pieces of plywood to fit snugly into the openings and apply a thin bead of adhesive along the rabbets and on the contacting exteriors of the plywood.
- Spread the glue equally, set the panels in position, and then utilize small finishing nails to secure them at 6 to 8 inch intervals.

How to install cockbeading

1 - Preparing the safe for cockbeading

- Cut a rabbet around the inside edge of the front frame of the safe, utilizing the same procedure you followed for the back panels.
- This time, install $\frac{1}{4}$ inch piloted rabbeting bit in your router and adjust the cutting depth to about $\frac{1}{4}$ inch.
- Keep the bit's pilot bearing butted against the stock as you make the cut, and then square the curves with a chisel.

2 - Milling the cockbeading

- Make enough cockbeading from $\frac{1}{4}$ thick stock to fit the rabbets cut in step 1, shaping it with molding cutters on a table saw.
- Do not utilize narrow stock; instead, cut pieces that are at least 4 inches wide and then rip the cockbeading from them.
- Install an auxiliary fence and raise the molding head into the wood fence to notch it.
- Use a feather board to secure the work piece; screw it to a shim so the pressure will be applied against the middle of the stock.
- To adjust the cut, center an edge of the board over a cutter, then butt the fence against the face of the stock.
- Hold the work piece flush against the fence and the table as you feed it into the cutters.
- Shape the opposite edge of the board the same way.
- Once all your stock has been milled, install a rip blade on the saw and cut the cockbeading from the boards, making it wide enough to protrude by $\frac{1}{4}$ inch from the rabbets in the safe.

3 - Gluing down the cockbeading

- Cut the cockbeading to fit inside the front frame, mitering the ends.
- Cut and fit one piece at a time, aligning the mitered ends with the curves of the rabbets.
- Spread a little glue on the contacting exteriors.

- Use any suitable clamp to secure the cockbeading along the top and bottom of the opening, protecting the stock with wood pads; for the sides, wedge thin wood strips rather longer than the gap amongst the cockbeading.

How to fasten the top panel

1 - Making the wood buttons

- If you are utilizing wood buttons to install the top on the pie safe, you will need to make enough buttons to space them every 6 inches along the ends and edges of the panel.
- You can mass-develop the buttons from a single board of a thickness equal to the gap amongst the top edge of the top frame rails and the grooves you cut in the rails, less than 1/16 inch.
- Cut a 3/8 inch rabbet at each end of the board, then rip it into 1-inch-wide strips and cut off the buttons about 1 ½ inches from the ends.
- To make screw holes in the buttons, install a 3/16 inch bit in your drill press and fashion a corner jig from ¾ inch plywood and L-fashioned support brackets.
- Clamp the jig to the machine table and steady the buttons with a push stick.
- Drill through the center of the unrabbeted portion of each button.

2 - Installing the top

- Set the top panel face down on the shop floor and position the safe upside down on top of it.
- Align the back of the cabinet with the back edge of the top and center the safe amongst the panel edges.
- Starting near the curves, fit the rabbeted ends of the wood buttons into the grooves in the top rails; space the buttons about 6 inches apart and leave a 1/8 inch gap amongst the bottom of the grooves and the lipped ends of the buttons to allow for wood movement.
- Drive screws to fasten the buttons in place.

How to install crown molding

1 - Cutting the molding

- Fit a moldings head with bevel cutters and mount the head on your table saw.
- Install and notch an auxiliary wood fence, and position the fence for the desired profile.
- Secure the stock you will utilize to make the molding with two feather boards, clamping one to the fence above the blade, and a second to the saw table.
- Clamp a support board at a 90 degree angle to the second feather board.
- Raise the cutters 1/8 inch above the table; do not make a full depth cut in one pass.
- Press the stock against the fence as you slowly feed it into the cutters; finish the cut with a push stick.
- Reverse the board and repeat the cut on the other edge.
- Make as numerous passes as necessary, raising the cutters 1/8 inch at a time, until you have reached the desired depth of cut.
- Install a rip blade on the saw and cut the molding from both sides of the work piece.

2 – Installing the side molding

- Fasten one side molding first, then the front piece, and Lastly the remaining side piece.
- Cut the molding pieces to length, mitering their ends.
- Spread some glue on the contacting exteriors amongst the first side piece and the top rail of the side and set the piece in position.
- To allow for wood movement, do not apply any glue amongst the molding and the top of the case.
- Clamp the front piece to the front rail-without glue-to help you align the side piece appropriately.
- Install two bar clamps along the top to secure the side piece in place, tightening the clamps gradually until a thin bead of glue squeezes out from the joint; utilize wood pads to protect both the

molding and the top.

3 - Installing the front molding

- Once the side molding has been secured, eliminate the clamps holding the front piece in place and apply glue to it and to the front rail of the pie safe.
- Also spread some adhesive on the mitered ends of the molding.
- Use hand screws to clamp the front molding to the cabinet, spacing the clamps about 6 inches apart.
- Lastly, install the remaining side piece as you did the first one.

Chapter 12 How to make an adjustable shelving

Adjustable shelving would no doubt have appealed to shaker furniture makers. The feature gives a cabinet flexibility adapting to changing needs and enabling the user to organize space most efficiently.

The shelves can be held in place with shelf supports that fit in holes drilled in the stiles. Another option is shop-made wooden corner strips, which are dadoed and attached to the interior curves of the pie safe to hold up the shelving.

How to utilize corner strips

1 - Making the corner strips

- You can make four strips, one for each corner of the pie safe, from a single 4- inch wide board that is long enough to extend from top to bottom of the cabinet.
- Install a dado head on your table saw and set the width equal to the thickness of the shelf supports you will use.
- Determine the desired spacing of the notches-typically about 2 inches and cut two dados that distance apart in a miter gauge extension board.
- Align the left-hand dado with the blades and screw the extension to the gauge with the other dado offset to the right.
- Cut a 2-inch piece of shelf support stock and fit it into that dado, where it will serve as an indexing key.
- Cut your first dado about 8 inches from one end-or at whatever height you want your lowest shelf.
- Cut the second and subsequent dados by moving the piece to the right and fitting the previous dado over the key.
- When the dados are all cut, rip the board into four 1 inch-wide corner strips.

2 – How to install the corner strips and shelf supports

- Spread some glue on the contacting exteriors amongst the corner

strips and the stiles of the pie safe, and position each strip, making sure that the dadoes face the interior of the cabinet.

- To clamp the strips in place, utilize thin wood scraps rather longer than the gap amongst the strips.
- For the shelf supports, measure the distance amongst the front and back stiles of the safe and cut the pieces to fit.
- Ensure that the supports are wide enough to hold the shelves securely.

3 - Preparing the shelves

- All four curves of each shelf must be notched to fit around the corner strips. Measure and mark each shelf, clamp it face down to a work exterior, and cut out the curves with a backsaw.

Chapter 13 How to make tin panel doors

The doors of the pie safe are joined with the open version of the mortise-and-tenon joint used to assemble the cabinet. The reinforcing pegs will prevent the joints from racking, even under the heaviest use.

You can make the joint on your table saw with a shop-made jig. Once the doors are assembled, they are rabbeted to accept the tin panels. A diversity of special punches are obtainable for piercing the panels themselves. Once the panels are installed, the doors can be mounted to the safe with straightforward butt hinges.

1 – How to cut the tenon cheeks in the rails

- Cut open mortise and tenons on your table saw utilizing the shop-made jig.
- Making sure the thickness of the spacer and width of the brace enable the jig to slide along the rip fence without wobbling.
- Cut the body and brace from $\frac{3}{4}$ inch plywood and the guide and spacer from solid wood.
- Saw an oval hole for a handle in the jig body and attach the guide to the body in front of the handle.
- Screw a wood block to the body below the handle and attach a toggle clamp to the block.
- Lastly, fasten the spacer and brace in place.
- To cut the tenon cheeks in the door rails, butt the work piece against the guide and clamp it in place.
- Set the cutting height to the tenon length, position the fence to align one of the cutting marks on the rail with the blade and slide the jig along the fence to make the cut.
- Turn the rail around to cut the other cheek, and then repeat the cuts at the other end of the rail and at both ends of the remaining rails.

2 – How to cut the tenon shoulders

- Screw a board to the miter gauge as an extension.
- Then, holding one of the door rails against the extension, adjust

the blade height to the depth of the tenon shoulder.

- Align the shoulder with the blade, butt a notched stop block against the stock, and clamp the block to the extension; the notch in the stop block will prevent sawdust from accumulating amongst it and the work piece.
- Holding the rail flush against the extension and the stop block, feed the stock with the miter gauge to cut the first shoulder.
- To saw the opposite shoulder, turn the rail over.
- Repeat to cut the tenon shoulders at the other end of the rail and in the remaining rails.

3 - Cutting the mortises in the stiles

- Use the tenoning jig to saw the mortises in the door stiles.
- Outline the mortises on the ends of the stiles, utilizing a completed tenon as a guide.
- Then clamp one of the stiles to the jig, rearrange the blade height to the tenon length, and position the fence to align one of the cutting marks with the blade.
- Slide the jig along the fence to cut one side of the mortise, and then turn the stile around to cut the other side.
- Reposition the fence and make as numerous passes as necessary to clear out the waste amongst the kerfs.
- Repeat the cuts at the other end of the stile and at both ends of the remaining stiles.

4 - Gluing up the door frames

- Dry fit the rails and stiles of the doors and utilize a chisel, if necessary, to fine-tune any ill-fitting joints.
- Spread glue on the contacting exteriors of the mortises and tenons, then utilize bar clamps to secure the joints, aligning the bars with the rails.
- Use wood pads to protect the stock and tighten the clamps until a little glue squeezes out of the joints.

5 - Preparing the door frames for panels

- Once the adhesive has cured, eliminate the clamps and secure the frames inside face up on a work exterior.
- To cut the rabbets in the frames for the tin panels, install a piloted 3/8 inch rabbeting bit in a router.
- While your final depth will equal the combined thickness of the panels and the molding you will be installing typically 3/8 inch adjust the bit to cut the rabbets in two or more passes.
- Rout the rabbets moving clockwise around the inside edges of the panel openings, keeping the bit's pilot bearing pressed against the stock throughout each cut.
- Once you reach your final depth, square the curves of the rabbets with a chisel.

6 – How to prepare the door frames for the false mullion

- To enable the pie safe doors to close appropriately, cut a rabbet along the inside face of both doors at their contacting edges; a wood strip, known as a false mullion, will be glued into the rabbet of the left-hand door so the doors will rest flush when closed.
- The 1/8 inch gap amongst the right-hand door and the edge of the mullion will prevent the doors from binding when they are closed in the end-on view in the inset.
- For the rabbets, install a dado head on your table saw and adjust its width to 1/2 inch and its height to 5/8 inch.
- Attach an auxiliary fence to your table saw rip fence, position the fence for the cutting width, and notch the wooden fence with the blades.
- To support the door frames, clamp a feather board to the fence above the dado head.
- Feed each frame inside-face down with both hands, keeping it flat on the table and pressed flush against the fence.

7 – Pegging the mortise and tenons

- Mark peg holes at all four curves of each door frame, centering them on the front face of the rails 1 1/2 inches from the side edge of the door.

- Install a 5/16 inch brad-point bit in your drill press, place a backup panel on the machine table to minimize tear out, and set one of the door frames on top, centering a drilling mark under the bit.
- Adjust the drilling depth to about two-thirds the thickness of the frame.
- Butt a board against the frame and clamp it in place as an edge guide.
- Then, holding the frame against the guide, drill the hole.
- Bore the remaining holes in both frames the same way.
- Cut a peg for each hole from a piece of solid stock, making it rather shorter than the depth of the holes,
- The pegs should be cut square, tapered at the bottom end and with a slight chamfer at the top.
- Tap each peg into its hole with a hammer, letting it protrude about 1/16 inch.

How to make the tine panels

1 – How to secure the pattern to the panel

- Tin panels and the equipment used to punch holes in them are obtainable from folk-art supply houses.
- The best way to punch the holes in the panels so they are all the same is to utilize a pattern as a template.
- Use a photocopier with an enlargement feature to develop a version of the desired pattern that is the same size as your panels.
- Then set one of the panels inside-face up on a backup board, center the pattern on the panel, and fix the paper to the tin with masking tape.
- To secure the panel to the backup board, utilize push pins, tapping them into the board every few inches around the perimeter of the panel

2 - Punching the holes

Use a hammer and the appropriate punch or chisel for the type of hole you wish to develop.

Holding the punch vertically on one of the pattern holes, strike the tool with the hammer.

A minimum amount of force is required to puncture the panel; the harder you strike the punch, the larger the hole will be.

Punch all the holes the same way, changing to a different punch or chisel as necessary.

If you are utilizing a metal other than tin for the panels, such as mild steel, you will need to file the sharp edges of the holes on the outside face of the panels. With tin, filing is not necessary

3 - Installing the tin panels and molding

- Make four strips of molding for each panel as you would for the glass doors of a wall clock.
- Then set the door frames outside-face down on a work exterior

and place a panel and molding in position.

- The sharp edges of the punched holes should be facing down.
- Bore pilot holes for finishing nails through the molding and into the frame every 2 inches, and then drive the nails utilizing a brad driver.
- To utilize the driver, insert a nail into a pilot hole, then position the jaws and tighten the locking nut.
- Holding the frame steady, squeeze the jaws to set the nail.

How to install the doors

1 – How to install the hinges on the doors

- Secure one of the doors hinge-edge up in a bench vise.
- Outline one hinge leaf about 6 inches from the top of the door and another 6 inches from the bottom.
- Then, holding a chisel vertically, score the outline and cut it rather deeper than the thickness of the hinge leaf.
- Hold the chisel bevel up to pare the waste from the mortise.
- Once you have cleared out the remaining mortises on both doors, set the hinges in their mortises, drill pilot holes, and screw them in place.

2 – How to install the hinges on the safe

- Position one of the doors in the cabinet, slipping two or three sheets of paper under the door as spacers.
- Use a bar clamp to hold the door in place, then mark the tops and bottoms of the hinge leaves on the inside edge of the front frame stiles.
- Eliminate the door, slip the pins out of the hinges, and outline the free hinge leaves on the safe, utilizing the marks you made to determine the height of the outlines.
- Ensure the hinge pins will protrude far enough from the safe so as not to bind against the cockbeading when the door is opened and closed.
- Chisel out the hinge mortises on the cabinet stiles as you did on the doors and screw the hinge leaves in place.
- Repeat the procedure with the other door.

3 – How to hang the door

- Once all the hinge leaves are installed, it is time to hang the door.
- Lift one of the doors into position so the hinge leaves on the door and the safe engage.
- Slip each hinge pin in place to join the leaves.

- Hang the other door the same way.

4 – How to install the false mullion

Cut the mullion from 1 -inch-thick stock, making it as long as the doors.

Size the width of the mullion equal to the gap amongst the shoulders of the rabbets you cut in the doors, less 1/8 inch.

The gap amongst the right-hand door and the edge of the mullion will prevent the doors from binding when they are closed.

Spread some adhesive in the rabbet in the left-hand door and on the contacting exteriors of the mullion, and set the strip of wood in place.

Clamp the mullion against both cheek and shoulder of the rabbet while the glue cures.

5 – How to install the door pulls

- Make a pull for each door on your lathe, turning around tenon at one end, or buy the pulls ready made.
- Mark a point in the middle of the contacting door stiles about two thirds of the way up the doors and drill a hole the same diameter as the tenons at each mark.
- Spread some glue on the tenons and insert each pull into it's hole.

Chapter 14 How to make a pegboard

The pegboard is a fitting symbol of the Shaker's approach to both daily life and craftsmanship. As with other Shaker-made items, the clean, unadorned lines of the pegboard reflected its humble function rather than any concern with appearance.

But the straightforward design belied the pegboard's versatility. The boards did not just hold hats and coats. Lining the walls of Shaker homes, they were an integral part of household life—convenient, organized, and tidy, hangers for each item from bookshelves, pipe holders, and towel racks to candle sconces, chairs, clothes hangers, and wall clocks.

For the modern woodworker, the pegboards also reveal the Shaker devotion to craft. The straightforward mushroom fashioned pegs were accorded the same attention to detail as the finest cabinet.

For this reason probably, Shaker pegboards were remarkably consistent in design and building no matter when or where they were made. The pegs were typically produced from maple or cherry and regular 3 inches in length.

They were secured to 3 inch wide back boards typically mounted 6 feet above the floor. The spacing of the pegs varied according to the board's use. In New Lebanon and Hancock, the pegs were every so often threaded and then screwed into the back board.

Typically, nevertheless, they were attached with a friction fit, as described in this section. You can buy pegs ready-made or turn them on your lathe. In either case, the base of the pegs will need to be kerfed to accommodate the wedges that secure them in place.

How to begin making a pegboard

1 - Shaping the back board

- Cut the back board to size from 7/8 inch thick stock; make its width 3 ½ inches and its length dependent on the number of pegs you will mount.
- Shape the board on a router table utilizing two different bits.
- Start by rounding over the front face of the board at the edges and ends, then switch to a piloted bead bit.
- Align the fence with the bit's pilot bearing and adjust the cutting height so the beads will be about ½ inch from the edges of the board.
- To help you feed the work piece, clamp a feather board to the table, braced with a support board.
- Feed the back board into the bit on edge, keeping the front face pressed against the fence.
- Then turn the board over and repeat the procedure to rout the bead on the opposite edge.

2 - Preparing the back board for the pegs

- Starting near one edge of the back board, mark the peg holes along the middle of the stock.
- Install a ½ inch brad-point bit in your drill press and attach a backup panel to the machine table to minimize tear out.
- Set the back board on the panel so the first mark is directly under the bit and clamp a board as a guide fence to the table flush against the work piece.
- Then, butting the back board against the fence, drill the holes.

3 - Tapping in the pegs

- To make the pegs easier to install, utilize a sanding block to shape a small bevel around the base of each one.
- Then saw a kerf for a wedge across the base of the peg; to avoid splitting the wood with the wedge, make the cut at a right angle to

the grain.

- Once the pegs are ready, spread glue on their bases and tap the pegs into the holes.

4 - Driving in the wedges

- For each peg, cut a 7/16 inch long wedge from scrap wood.
- Spread glue in the kerfs and on the wedges, set the pegboard face down on a work exterior, then tap the wedges in with a hammer.
- Avoid utilizing too much force; this may cause a peg to split.
- Trim the wedges flush with the back face of the board.
- Fasten the pegboard to the wall by counter boring screw holes and driving the screws into wall studs.
- Conceal the fasteners with wood plugs.

Chapter 15 How to make a drawer

Virtually all desks and numerous tables need drawers. And no matter what their use, all drawers must meet actually the same requirements. Whether you are making three or four sturdy drawers for a desk pedestal, or a single unit for an end table, each drawer must fit precisely and withstand considerable stress, while also complementing the design of the furniture that holds it.

The first step in building a drawer is to review its use. What will the drawer comprise? How much utilize will it receive? These matters will determine the type of wood and joinery you select.

Start with the drawer front. It is not just the most visible piece, it also undertakes the most stress. A solid, durable joint is required to keep it firmly attached to the sides. The front should also blend eye-catchingly with the grain of the wood surrounding it.

For structural reasons, the grain of the front should run horizontally. Vertical grain will not develop solid joints; it will also be prone to greater movement with moisture changes. The stock you utilize for the drawer sides and back does not have to be the same as for the front-provided you select durable wood that is resistant to warping.

Ash, oak, maple, and cherry are all robust enough to withstand heavy use. Softer species like pine and poplar are usable, but just for smaller drawers. Some cabinetmakers select contrasting woods like walnut and ash for the front and sides to highlight the joinery when the drawer is opened.

Beyond appearance and strength, a drawer must fit perfectly. A drawer that jams or chatters when it is opened and closed will wear more rapidly than one that whispers quietly. There are several ways to mount drawers.

Each technique is intended to support the drawer, prevent it from tipping as it is pulled out, and stop it as it slides home. Drawer stops presents several effective ways to stop drawers from being pulled out or pushed in too far.

Hardware adds the final touch to a drawer. The selection offers some suggestions. Locks are applied to drawers both for securing valuables and to copy traditional pieces.

A drawer is actually an open box, consisting of a front, a back, two sides, and a bottom. The front is most often made from denser stock than the sides and

back; the bottom is typically made from ¼ inch plywood.

Beyond these general similarities, drawers vary in style, techniques of joinery, and techniques of mounting. Installing a drawer can be a tricky operation, especially if the drawer is poorly made.

An out-of square drawer can every so often be concealed with a false front, but if it is badly twisted, it will be almost impossible to install so that it opens smoothly.

Several joints for assembling drawers are also required and each possesses different qualities of strength and resilience. Installing hardware is the final, and typically the straightforwardst, step in building a drawer.

When you have settled on the size of a drawer, it is time to select the right joinery. Since the curves of a drawer undertake different stresses, select your joints accordingly.

The front to side connections remain the most stress and require the robustest joinery. The connections amongst the back and sides are less affected by everyday utalize and Thus do not have to be as solid.

The joinery options you select will also affect the appearance of the drawer. Unless you are installing a false front, select a joint like the half-blind dovetail or double dado to conceal the end grain of the sides.

Drawer bottoms fit into a groove cut in the sides and front. The groove can be cut with a saw before the joinery cuts are made or once the drawer is assembled, utalizing a table-mounted router and a three-wing slotting cutter.

Before gluing up, ensure you have decided on a mounting technique. A side hung drawer, For instance, needs to have a groove cut in its side before the drawer is assembled.

Before you begin cutting, select the most eye-catching face of each part and mark it with an X to designate it as the outside of the drawer. Reserve the most visually appealing piece for the front.

How to make a half-blind dovetail joint

1 - Marking the pin board

- Mark the outside faces of all the boards with an X.
- Then set a cutting gauge to about two thirds the thickness of the pin board-the drawer front-and mark a line across the end, closer to the outside than the inside face.
- Adjust the cutting gauge to the thickness of the drawer sides and scribe a line on the inside face of the front to mark the shoulder line of the tails.
- Then, utilize a dovetail square to outline the pins on an end of the front; the wide part of the pins should be on the inside face of the stock so the front does not pull away from the sides.
- There are no strict guidelines for spacing dovetail pins, but for most drawers, a half-pin at each edge and two equally spaced pins in amongst makes a robust and eye-catching joint.
- To complete the marking, secure the front in a vise and utilize a try square and a pencil to extend the lines on the board end to the shoulder line on its inside face.
- Mark the waste sections with X-s as you go.

2 - Gutting the pins

- Secure the drawer front in a vise with the inside face of the stock toward you, then cut along the edges of the pins with a dovetail saw, working your way from one board edge to the other.
- Some woodworkers prefer to cut all the left-hand edges of the pins, then move on to the right-hand edges.
- Hold the board steady and align the saw blade just to the waste side of the cutting line; angle the saw toward the waste to avoid cutting into the pins.
- Use smooth, even strokes, allowing the saw to cut on the push stroke.
- Continue the cut to the shoulder line, and then repeat to saw the pins at the other end of the board.

3 – How to chisel out the waste

- Lay the drawer front inside-face up on a work exterior and clamp a guide block to it, aligning its edge with the waste side of the shoulder line.
- Starting at one edge of the stock, hold the flat side of a chisel against the guide block; the blade should be no wider than the narrowest portion of the waste section.
- With the chisel perpendicular to the board face, strike the handle with a wooden mallet, making a 1/8 inch deep cut into the waste.
- Then hold the chisel bevel-up about 1/8 inch below the board face and peel away a thin layer of waste.
- Continue until you reach the scribed line on the end of the board.
- Repeat the procedure with the remaining waste sections, and then pare away any excess waste.

4 - Final paring

- Working on one tail socket at a time, eliminate the remaining waste from amongst the pins.
- First press the flat side of the chisel against the bottom of the socket with the thumb of your left hand; with your right hand, push the chisel toward the shoulder line, shaving away the last slivers of waste when pare away any waste from the sides of the pins.

5 - Laying out the tails

- Set one drawer side outside-face down on the work exterior.
- Hold the drawer front end-down with its inside face aligned with the shoulder line of the tail board, making certain the edges of the boards are flush.
- Outline the tails with a pencil, and then utilize a try square to extend the lines on the end of the board.
- Mark all the waste sections with X-s.

6 - Cutting the tails

- Use a dovetail saw to cut the tails the same way you cut the pins Step 2.
- Angling the board, rather than the saw, makes for easier cutting.
- Secure the board so that the right-hand edges of the tails are vertical.
- Saw smoothly and equally along the edges of the tails, stopping at the shoulder line.
- Reposition the board in the vise to cut the left-hand edges.
- Once the entire saw cuts have been made, eliminate the waste with a chisel as in steps 3 and 4.
- To avoid splitting the tails, eliminate about half the waste, then flip the work piece over to chisel out the remaining waste.

7 – Preparing the drawer for a bottom panel

- Dry fit the drawer and mark any spots where the joints bind; utilize a chisel to pare small amounts of wood to achieve a good fit.
- Loose joints can be tightened.
- Then, utilize your table saw to cut a groove in the drawer front and sides to accommodate the bottom.
- Install a dado head, adjusting its width to the thickness of the stock you plan to utilize for the bottom typically $\frac{1}{4}$ inches.
- Mark the groove on the drawer front and sides; the groove should be located just above the half-pin at the bottom edge of the front.
- Align the groove mark with the dado head and position the rip fence against the edge of the stock.
- Adjust the blade height for the depth of the groove, no more than one-half the stock thickness.
- Feed the drawer front across the table utilizing a push stick.
- Repeat the cut on the drawer sides.
- Then install a combination blade and trim the bottom of the back flush with the top of the grooves in the sides and front.
- This will allow the bottom to slide into position when the drawer is assembled.

8 - Gluing up the drawer

- Before assembling the drawer, cut a bottom panel from $\frac{1}{4}$ inch plywood or solid stock to fit the drawer opening, adding the depth of the grooves to its width and the depth of one groove and the thickness of the back panel to its length.
- To glue up dovetail joints, clamping pressure should be applied to the tail boards.
- To distribute clamping pressure appropriately, make a specially notched clamping block for each joint.
- Each block should be as long as the width of the stock and notched so it just touches the tails and does not exert pressure on the pins.
- Spread glue equally on all the contacting exteriors of the boards and assemble the joints.
- Install a bar clamp along each pin board, then tighten the clamps a little at a time.
- Confirm the drawer for square and adjust the clamping pressure, if necessary.

How to make through dovetails

1 – How to mark the pin board

- The through dovetail is similar to the half-blind joint, except that the tails extend fully through the pin board.
- To begin marking the joints, make an X on the outside faces of all the boards. Then set a cutting gauge to the thickness of the stock and scribe a line along both ends of the boards to mark the shoulder of the pins and tails.
- Then secure the drawer front end-up in a vise and utilize a dovetail square to outline the pins on the end of the board; the wide part of the pins should be on the inside face of the stock.
- As with the half-blind dovetail, the spacing is a matter of personal choice, but for a typical drawer, a half-pin at each edge and two equally spaced pins amongst provide a good combination of strength and appearance.
- Mark the waste sections with an X as you go.
- Lastly, utilize a combination square to extend all the dovetail marks down both faces of the board to the shoulder lines.

2 - Cutting the pins

- Leave the drawer front in the vise with its outside face toward you.
- Use a dovetail saw to cut along the edges of the pins, aligning the saw blade just to the waste side of the cutting line.
- Cut all the right-hand edges, and then complete the left-hand edges.
- Use smooth, even strokes, taking care to keep the blade level as you cut to the shoulder lines.
- Once the pins are cut, leave the board in the vise and utilize a coping saw to eliminate as much of the waste as possible amongst the pins.
- At the side of each pin, slide a coping saw blade into the kerf and rotate the frame without striking the end of the board.
- Keep the blade about 1/16 inch above the shoulder line as you cut to the kerf on the edge of the adjacent pin.

- Pare away any remaining waste with a chisel as you would for half-blind dovetails.
- Repeat the procedure at the other end of the drawer front and for the back of the drawer, then mark and cut out the tails on the drawer sides.

Hand-cutting dovetail joints for a large number of drawers take considerable time and practice. Your router, paired with a commercial dovetail jig, provides an efficient alternative.

While router-and-jig cut dovetails may lack the hand-crafted look of sawn and chiseled joints, they are just as robust, fit together as well and, most vitally, can be developed in a fraction of the time.

But recall factoring in setup time for the jigs. If you are making just a couple of drawers, hand equipment may well be a faster alternative. Three popular dovetail jigs.

Depending on which template is used, the jig enables a router to cut the pins and tails for half blind, through dovetails, or box joints with a single setup. The jig in the center consists of two fixed templates for cutting through dovetails.

The templates are fastened to backup boards that support the work piece. One template is used for cutting the pins, the other for the tails. The jig on the right can be used for routing both half-blind and through dovetail joints.

Its single adjustable template allows you to vary the size and spacing of the pins and tails, giving the joints more of a hand-crafted look. All three jigs work on actually the same principle.

A router is fitted with a dovetail bit and a guide bushing-both typically provided with the jig. By feeding the tool along the template, the bit is guided in and out of the slots to cut away the waste.

Once the templates have been attached to backup boards, the pin and tail boards are secured in place.

For several identical joints, a stop block can be clamped to the backup boards for repeat cuts.

How to make double dado joints

1 - Cutting dados in a drawer front

Mark one end of the board, dividing its thickness into thirds.

Then, install a dado head on your table saw, adjusting the width to one-third the thickness of the drawer front.

Set the cutting height equal to the thickness of the drawer sides.

Then, install a commercial tenoning jig; slides in the miter slot.

Protecting the stock with a wood pad, clamp the drawer front to the jig.

Move the jig sideways to align the marks so that the blades cut the dado in the middle third of the board.

Slide the jig along to feed the stock.

Turn the drawer front over and clamp it to the jig to cut the dado at the other end.

2 - Trimming the dado tongues

Install a wooden auxiliary fence on the rip fence, then mark a cutting line on the edge of the drawer front that divides one of the tongues on its inside face in half.

With the stock flush against the miter gauge, inside face down, align your mark with the dado head.

Butt the fence against the stock and raise the blades to cut a relief notch in the fence.

Set the cutting height to trim the half-tongue.

Holding the drawer front firmly against the gauge, feed it into the dado head. Turn the board around and repeat the procedure at the other end.

3 - Cutting matching dados in the drawer sides

- To join the drawer sides to the front, cut a dado near the front end of each side.
- The dado must mate with the half-tongue on the front.

- Set the cutting height to the length of the half-tongue and screw a wooden extension board to the miter gauge.
- To set the width of cut, butt the drawer side against the front and utilize a pencil to outline the half-tongue on the drawer side.
- Hold the side against the extension and align the marks with the dado head.
- Clamp a stop block flush against the end of the stock and feed the board to cut the dado.
- Repeat the cut on the other side.

How to cut a lipped rabbet in a drawer front

- To cut lipped rabbets around the edges of a drawer front, mark lines on its inside face to allow for an overhang of at least 3/8 inch.
- Also mark the rabbet depth on its edges-up to one-half the thickness of the drawer front.
- Cut the rabbets on the table saw in two steps, first notching the inside face of the front with the blade height set to the depth of the rabbets.
- These cuts are made with the stock face down on the saw table.
- Then feed the stock into the blade on end and on edge.
- Set the blade height to the width of the rabbets, align the blade with the marks for the rabbet depth, and butt the fence against the stock.
- Keeping the drawer front flush against the fence, feed it on end into the blade to complete one rabbet.
- Turn the board over and repeat to cut the rabbet at the other end.
- Then feed the stock into the blade on edge to cut the rabbets on the top and bottom edges.

How to utilize bar clamps

- Before gluing up a drawer, decide how you will install it, since side-mounting may require you to prepare the drawer sides before final assembly.
- Apply glue on all the contacting exteriors of the joints and assemble the drawer.
- Arrange two bar clamps on a work exterior and lay the drawer on them, aligning the bars of the clamps with the drawer front and back.
- Install two more clamps along the top of the drawer.
- If you used rabbet joints to assemble the drawer, install another two clamps along the drawer sides.
- Protect exteriors by placing wood pads amongst the stock and the clamp jaws.
- Tighten the clamps just enough to close the joints fully, and then confirm the drawer for square.
- Finish tightening the clamps until a bead of glue squeezes out of the joints, checking as you go that the corners are square.
- Once the adhesive has dried, scrape away any dried glue.
- Slide the bottom panel into place and secure it with finishing nails driven up into the drawer back.

How to install the bottom with drawer slips

1 - Making the slips

- For drawer sides made from stock that is too thin to be grooved for a bottom panel, install drawer slips.
- Slips also provide greater bearing exterior for bottom-run drawers.
- Before the drawer is assembled, prepare your slip stock from a strip of wood-1 by 1 stock is appropriate for most drawers at least as long as the combined length of the drawer sides.
- Round over one corner of the board, then set up your table saw to cut a groove in it.
- Install a dado head, adjusting its width to the thickness of the bottom you will use, and set the cutting height to about 3/8 inch.
- Position the slip stock flush against the bottom edge of the drawer front and mark the location of the groove on the board.
- Align the mark with the dado head and position the rip fence against the stock.
- Clamp on two feather boards to support the work piece.
- Saw the groove, and then crosscut it into two lengths equal to the drawer sides measured from the drawer front.

2 - Mounting the slips on the drawer

- Notch the slips so that they clear the back, then set the glued-up drawer upside down on a work exterior, spread some glue on the contacting exteriors of the slips, and clamp them against the sides and drawer front.
- Make certain that the grooves in the slips and drawer front are perfectly aligned.

How to install a half mortise lock

1 – How to center the lock

- Set the drawer on a work exterior and mark the midpoint amongst the sides on the top edge of the front.
- Then utilize a combination square to extend the mark onto the inside face of the front.
- Then, hold the lock faceplate against the inside of the drawer front, aligning the keyhole with the center mark and keeping the faceplate lip flush with the top edge of the drawer front.
- Use a pencil to outline the faceplate on the inside face and top edge of the front.

2 – How to cut the lock mortise

You need to cut three mortises for the lock: one for the faceplate, another for the lock housing, and a third for the faceplate lip.

This is one of the rare cases when the router is used freehand. Install a straight bit in the tool, set the cutting depth to the thickness of the faceplate, and cut a mortise inside the marked outline for the faceplate.

Start by guiding the tool in a clockwise direction to cut the outside edges of the mortise; clear out the remaining waste by feeding the tool against the direction of bit rotation.

Use a chisel to square the curves and pare to the line.

For the lock housing, measure the distance amongst the edges of the faceplate and housing and transfer the measurement to the first mortise.

Adjust the router's cutting depth to the thickness of the housing and cut its mortise.

Then, utilize the chisel to cut the recess in the top edge of the drawer front for the faceplate lip.

Test the fit of the lock in the cavity and utilize the chisel to deepen or widen any of the mortises, if necessary.

3 – How to cut the keyhole

Set the lock in the mortise and mark the location of the keyhole.

You need to drill two holes for the key: one for the shaft and a smaller hole for the key bit below it.

Bore the wider hole first with a bit rather larger than the key shaft.

Then utilize a bit rather larger than the thickness of the key bit to bore the second hole.

Use a coping saw to join the two holes.

To finish installing the lock, mount an escutcheon on the outside face of the drawer to protect the wood surrounding the keyhole.

Chapter 16 How to mount drawers & drawer stops

There are several ways to install drawers in a desk or table. The technique you select should suit the design of your piece and the loads you expect the drawers to bear. The straightforwardst way to mount a drawer is with side runners.

This technique involves routing grooves in the drawer sides before assembly. These mate with sides mounted on the inside of the casework. Side mounting is ideal in frame and panel casework and for small to medium sized drawers that will bear moderate loads.

Commercial slide runners are another technique of side-mounting drawers in a carcass. While purists may decry their use, commercial runners are robuster than wood runners, and so is a wood choice for drawers that will bear heavy loads.

Commercial runners are obtainable in different sizes. Buy the hardware and read the manufacturer's instructions before you build your drawers, since runners require specific clearances amongst the drawer sides and the carcass.

The robustest technique of securing drawers is bottom-mounting. Here, the drawers ride on runners mounted in grooves milled in the sides of the casework.

The runners are joined at the front and the rear with stretchers, which provide both a bearing exterior for the drawers and strengthen the casework. Dust panels can be added to the frame formed by the runners and stretchers by setting them in a groove routed in their inside edges.

Some woodworkers prefer to rout a groove in the carcass sides and install a shelf, which serves double-duty as drawer support and dust panel.

How to side mount a drawer in a carcass

1 – How to cut grooves in the drawer sides

- Cut a groove in the outside face of each drawer side before final assembly.
- There are no rigid guidelines for the groove width, but it should accommodate slides that are hefty enough to support the drawer.
- On your table saw, install a dado head the same width as the groove.
- Draw cutting lines for the groove width to the middle of the leading end of one drawer side.
- Set the cutting height at no more than one-half the stock thickness.
- Butt the lines for the groove width against the dado head, position the rip fence flush against the stock, and make the cut.
- If the groove width exceeds the width of the dado head, turn the board end for end and make another pass.
- Repeat to cut the groove in the other drawer side.

2 – How to make and install the drawer slides

- On your table saw, rip the drawer slides from a board that is rather shorter than the depth of the carcass.
- Position the rip fence to a cutting width rather narrower than the grooves in the drawer sides.
- Cut two slides for each drawer, utilizing a push stick.
- To mount the slides, insert the drawer in the carcass and hold it in place while utilizing a pencil to mark the location of the grooves on the front edges of the side panels.
- Then utilize a carpenter's square to extend the marks across the inside faces of the panels.
- Bore three countersunk clearance holes through the slides; make the clearance hole rather wider than the screw shanks to allow for wood movement.
- Holding the slides recessed from the front edge of the carcass amongst the marked lines on the side panels, drill pilot holes and screw the slides in place.

- Test fit the drawer.
- Use shims under the slides to tighten it or deepen the grooves to ease the fit.

How to side mount a drawer in a frame and panel case

1 – How to make the corner strips

- Rip a board to a width of 4 inches and crosscut it to reach from top to bottom inside the case.
- The dados for the drawer supports are easy to cut on a radial arm saw.
- Install a dado head, adjusting its width to accommodate the thickness of the supports you will utilize in step 3.
- Starting at the end that will be at the bottom of the cabinet, cut a dado for the lowest drawer.
- Slide the board along the fence to cut the second dado at the Then drawer position.
- If the distance amongst the supports will be equal, drive a screw into the fence to serve as an indexing pin; locate the head of the fastener against the left edge of the first dado.
- Now cut the second dado and reposition the board so the left edge of this dado rests against the screw head.
- Cut the remaining dados in this fashion, and then rip the board into four equal strips.

2 – How to install the corner strips

- Bore a clearance hole for a No. 8 screw near the end of each corner strip, and then with a larger bit, drill deep enough to recess the screw head.
- Now position each strip in the case, making certain that the dadoed edges are flush with the edge of the stiles.
- Temporarily hold the strips in place with hand screws, make and insert your drawer supports, and test the drawers in the case.
- Adjust the height of the corner strips, if necessary, to level the drawers.
- Then eliminate the drawers and drawer supports, mark the screw holes near the top and bottom of the stiles utilizing an awl, and bore pilot holes for a No. 8 screw.
- Screw the strips to the case.

3 – How to insert the drawer supports

- Measure the distance amongst the front and back stiles on both sides of the case.
- Cut drawer support so fit the gaps amongst matching pairs of dados.
- Ensure that the supports are wide enough to buttress the drawers adequately, and that they fit snugly in the dados.

How to plane drawer sides

- If a drawer binds in a piece of furniture, you can utilize a hand plane to improve the fit.
- If the sides bind, eliminate the drawer and find and mark any shiny areas on the sides-these are high spots that can be shaved with the plane.
- Secure the drawer on a work exterior so the binding side is facing up.
- Gripping the plane with both hands, shave off the marked spots with smooth, even strokes.
- Test fit the drawer in its opening and continue planing until it fits perfectly.

How to install drawer stops

- Drawer stops control how far a drawer can slide in or out.
- Inward stops are almost always required.
- They prevent a drawer from being pushed in too far.
- Outward stops, to prevent a drawer from pulling out of a carcass, are always required when a drawer carries a heavy load, and may be desirable at other times as well.
- The following pages will describe a few techniques for installing both types of stops.

How to attach an eccentric stop

- This is an easy-to-install adjustable stop.
- Before installing the back panel of your carcass, utilize a band saw or saber saw to cut a 1 to 1 ½ inch-diameter disk from a piece of scrap wood the same thickness as the drawer sides.
- Bore an off center hole through the stop, then screw the disk to the side panel near the back.
- Set the case on its side and close the drawer.
- Loosen the screw rather and rotate the stop until it just touches the drawer, then tighten the screw.

How to install an outward drawer stop

- Cut a stop from a piece of scrap wood.
- Before gluing up the drawer, cut a notch for the stop in the drawer back.
- Make the notch deeper than the stop's thickness and wider than its narrow dimension to allow the stop to fit through the opening when you install the drawer.
- For the desk pedestal, the stop is fixed to the underside of the shelf or dust panel.
- To mount the stop, install the drawer and mark the location of the notch on the frame above the drawer.
- Bore a pilot hole through the stop, and then screw it in position.
- Do not tighten the screw all the way.
- With the long edge of the stop parallel to the sides of the case, slip the drawer in place.
- Once the stop passes completely through the notch, rotate it 90 degree so that its long edge is parallel to the drawer back and tighten the screw.

How to install a stop on the front rail

- This technique works for the too drawer of a frame and panel desk or one with drawer rails amongst each drawer.
- Cut a drawer stop from scrap.
- To mount the stop, bore a pilot hole near one end.
- Screw the stop to the middle of the rail, leaving the fastener just loose enough so that you can rotate the stop out of the way. Install the drawer.
- Once the drawer back clears the front rail, rotate the stop 90 degree.

Chapter 17 How to design a desk

- Casework is the fundamental building block of most desks.
- It can be as straightforward as a four-sided box or as elaborate as a frame and panel cabinet.
- Such elements as dividers, shelves, drawers, face frames, and dust panels provide refinements that transform this casework into a piece of furniture.
- The following chapters will teach you how to apply casework techniques to the building of a two pedestal desk.
- Carcases are easier to build than frame-and-panel cabinets.
- All carcasses should consist of four panels joined to form a box.
- Ensure that the wood grain of all the panels runs in the same direction.
- This will allow the panels to swell and shrink at the same rate as relative humidity levels change.
- If you assemble a carcass with the grain of adjacent panels at right angles to each other you risk splitting one of the panels.
- The second type of casework frame and panel solves the issue of wood movement by allowing space for swelling and shrinkage.
- Individual frame-and-panel assemblies should be joined to form a case.
- The opening in each frame is filled by a panel that rests in grooves cut in the inside edges of the frame.
- While the frame pieces are glued together at the corners, the panel is set into the frames without adhesive to allow it to swell and shrink.
- The panel is often beveled around the edges—a decorative touch that also allows it to fit more simply into its groove.
- The technique you select for assembling a carcass or frame and panel case will influence the character and individuality of your desk.
- The rabbet joint works well with either solid wood or plywood panels.
- Through dovetails are more time-consuming to make but they are more eye-catching and reviewed a sign of fine craftsmanship.
- Frame-and-panel assemblies can be put together with mortise and

tenons or the more decorative cope-and-stick joint.

Chapter 18 How to build a carcass

Four panels joined to form a box: The carcass is the straightforwardst and most basic building block of furniture building. A carcass provides the rigid framework for items as diverse as a bookcase and a drawer.

Build two boxes and join them together and you have the heart of an eye-catching two pedestal desk. The section that follows describes how to do this. Carcass Panels can be constructed from plywood, but for fine furniture, the panels are most often made from narrow boards edge-glued into wider panels.

The panels are then planed, jointed on one edge, cut to size, and sanded. To allow the panels to contract and expand with changes in humidity the grain of all panels in a carcass is aligned in the same direction.

Carcasses can be assembled with several types of joints. The rabbet joint is a popular choice: The joint offers a large gluing exterior and is straightforward to make. The rabbets are best cut into the side panels so that the end grain of the top and bottom panels will be covered.

The end grain of the sides is often concealed by the top. When planning a carcass, it is wise to take into consideration the type of shelving or drawers that will be built into it.

For instance, if the desk features dust frames that both support the drawers and provide strength to the carcass, the joinery needs for these frames must be taken into account before the carcass is glued up.

How to prepare the rabbet joints

1 – How to cut rabbets in the carcass sides

- The rabbet width should equal the thickness of the carcass top; mark a cutting line for the rabbets on the leading edge of one side panel.
- Install a dado head rather wider than the rabbet on your table saw.
- Attach an auxiliary wood fence to the rip fence and raise the dado head to cut a notch in the wood fence.
- Set the cutting height at one-half the stock thickness and adjust the fence for the width of cut.
- Clamp a feather board to the fence directly above the blade to hold the panel securely against the table, then make the cut.
- Cut a rabbet at the opposite end of the panel and both ends of the other side panel.

2 – How to cut grooves for the back panel

- Once you have rabbeted the carcass sides, you need to prepare the four panels to accommodate the back, which can be set into a rabbet or a groove.
- For the rabbet, repeat step 1, but make the cut along the back edge of each panel and adjust the cutting depth to the thickness of the back typically $\frac{1}{4}$ inch.
- For the groove, adjust the dado head to a width of $\frac{1}{4}$ inch, then position the fence so the groove will be $\frac{1}{4}$ inch from the back edge of the panel.
- Cut the back from $\frac{1}{4}$ inch plywood to fit the opening in the carcass, adding the depth of the grooves to its dimensions

How to make a dust frame

1 – How to cut twin tenons in the front rails

- The dust frames that will support the drawers are joined to the desk pedestals with twin mortise and tenon joints.
- Start by cutting the tenons in each front rail on your table saw; they will fit into matching mortises in the carcass side panels.
- Equip your table saw with a dado head $\frac{1}{4}$ inches wide, and then install a tenoning jig in the miter slot.
- Mark a twin tenon at each end of the rail, and set the cutting height at X inch.
- Clamp the rail to the jig end up and shift the jig sideways to align one of the tenon marks with the dado head.
- To make the cut, push the jig forward, feeding the stock into the blades.
- Turn the rail around to cut the other tenon shoulder.
- Repeat the cuts at the other end of the rail and at both ends of the remaining rails.

2 – How to clear the waste amongst tenons

- Shift the tenoning jig to line up the dado head with the waste amongst the twin tenons.
- Make several passes until you have cleared away the excess wood.

3 – How to chisel the double mortises in the carcass sides

- Mark lines on the inside face of the side panel for the location of each dust panel.
- Place the rail face down on the panel, aligning the edges of both and positioning the end of the rail flush with the top line.
- Outline the twin tenons on the panel.
- Repeat for the other rails.
- To chop out the mortises, clamp the panel to a work exterior.
- Then, starting at an end of one outline, hold a mortising chisel square to the face of the panel and strike the handle with a wooden

mallet.

- Use a chisel the same width as the mortises and be sure that the beveled side is facing the waste.
- Continue making cuts at intervals of about 1/8 inch until you reach the other end of the outline.
- Use the chisel to lever out the waste to the required depth.
- Chop out the adjacent mortise and the other double mortises the same way.
- Test fit the joint and widens or deepens the mortise with the chisel, as required.

4 – How to make the dust frames

- Prepare a rear rail, a floating ¼ inch plywood panel, and two stiles for each dust frame as you would for a non-raised frame and panel assembly, sizing the frame to fit the interior of the carcass.
- Instead of cutting rabbets, rout a ¼ inch-deep groove around the inside edge of the frame to accommodate the panel; the grooves will also serve as mortises for the stub tenons that join the rails and stiles together.
- Also rout a groove along the outside edge of each stile to accept the spline that will fit into a matching groove in a carcass side panel.

5 – How to glue up the dust frames

- Sand any exteriors of the frame that will be hard to reach after glue up.
- Spread adhesive on the tenons and their mating grooves.
- Do not apply glue in the panel groove; the panel must be free to move.
- Glue one of the stiles to one of the rails, insert the panel, and then assemble the other pieces.
- Clamp the dust frame across the joints with bar clamps, checking for square and utilizing wood pads to protect the stock.

How to glue up the carcass

1 – How to groove the carcass sides

- Each dust frame is secured to the carcass sides with stopped groove and spline joints that will enable the frame to move with changes in humidity.
- Each joint consists of a hardwood spline that will sit in matching stopped grooves routed in the carcass side and the stile of the dust frame.
- To cut the grooves in the carcass, install a ¼ inch straight bit in your router and secure one of the side panels inside face up to a work exterior.
- Clamp an edge guide to the panel so the bit will be centered on one of the double mortises you cut for the drawer rails.
- For each dust frame, rout a stopped groove starting about 1 inch from the mortises and stopping about 3 inches from the opposite edge.
- Repeat for the other carcass side.

2 – How to install the dust frames

- Cut two hardwood or plywood splines for each frame.
- The splines should be a little shorter than the grooves you cut in step 1 to allow for wood movement; for maximum strength, the grain should run across the spline's width.
- Place one side of the carcass inside face up on a work exterior, apply glue to the twin mortises and tenons, and set the frames in place, making sure that they fit snugly over the splines.

3 – How to assemble the carcass

- With all the dust frames in place and the remaining splines set in their grooves, assemble the rest of the carcass.
- First apply glue along the rabbets in one side panel and slide the back and bottom in position.
- Then, set the top in place.
- Spread some glue on the remaining twin mortise and tenons and cautiously lower the other side panel on top of the assembly,

guiding the splines into their grooves and the twin tenons into their mortises.

- Install bar clamps across the front of the carcass, aligned with each dust frame, and across both the top and bottom of the assembly.
- Use wood pads to protect the stock.
- Reinforce the rabbet joints and the back with countersunk nails or screws which can later be concealed with plugs.

How to install the connecting rail

1 – How to cut dovetailed half laps in the front connecting rail

- In a two pedestal desk, the carcasses are joined by connecting rails and a dust frame that supports a central drawer.
- The front connecting rail is joined to the carcasses with dovetailed half lap joints.
- To prepare each rail, cut it to size and saw a dovetailed half lap in each end with a dovetail saw.

2 – How to cut the mating dovetails in the carcasses

- Use one of the dovetailed half laps you cut in step 1 to outline the mating dovetail mortise in each carcass.
- Then utilize a saw and chisel to cut the mortise.
- Then, make a dust frame to fit amongst the carcasses and support the central drawer.
- Rout grooves and mortises on the outside of both carcasses to accommodate the joinery.
- Also cut a rail to span the carcasses at the back and hide the back of the drawer.
- Join this rail to the carcasses with blind mortise and tenon joints.
- Assemble and clamp the desk together.

How to base mold

1 – How to make the base molding

- The base moldings for the carcass is made from three pieces of molded stock and a brace.
- To prepare the molding, rout a decorative detail along one edge of each board, utilizing your table saw fitted with a molding cutter head or a table-mounted router with a molding bit.
- Then cut a rabbet in each piece along the opposite side of the same edge; this will form a lip to support the carcass.
- Saw the boards to length, beveling both ends of the front piece and just the front end of the sides.
- Also saw a bracing piece that will fit, faceup, amongst the sides at the back of the molding; bore a hole for a screw through the brace.
- The screw will attach the brace to the carcass.
- The boards will mate end-to-end, except at the back of the molding, where the brace is joined to the inside faces of the sides.
- A plate joiner with an adjustable fence makes it easier to align the tool when cutting the slots in the beveled ends.

2 – How to glue up the base molding

- Working rapidly, apply glue to all the slots, insert one biscuit for each joint, and assemble the base molding.
- Secure the brace to the sides with a bar clamp, utilizing wood pads to protect the stock; install a web clamp with corner brackets around the molding at the miter joints.
- Tighten the web clamp, utilizing the wrench provided, then tighten the bar clamp.
- Once the glue is dry, install the base by applying glue just along the rabbet in the front piece and set the carcass in place.
- This will cause any wood movement in the side pieces to take place towards the back of the molding, preventing the miters at the front from separating.
- Attach the brace to the carcass by driving a screw through the hole you drilled in step 1.

Chapter 19 How to build a frame and panel desk

Frame and panel building offers one solution to the perennial issue of wood movement. The principle is straightforward: A panel "floats" in a groove cut on the inside edge of a frame. The panel can be flat, as in a dust frame, or "raised," with bevels cut along its edge.

The beveling allows the panel to fit into a groove in the frame and presents a decorative face to the public. A panel can be raised on the router table or the table saw. To construct a frame and panel desk, you need to join four individual frame and panel assemblies: a rear assembly, a front assembly with drawer slides, four side rails, and two side panels.

1 – How to cut the tenons in the rails

- To join the rails and stiles of individual frame-and-panel assemblies with haunched mortise and tenons, install a dado head rather wider than the length of the tenons on your table saw.
- Attach an auxiliary fence and raise the dado head to notch it.
- Set the width of cut equal to the tenon length.
- To cut the tenon cheeks, butt the stock against the fence and the miter gauge, and then feed it face down.
- Turn the rail over and repeat the cut on the other side.
- Then, cut tenon cheeks at the other end of each rail.
- Position the fence to leave a haunch equal in width to the depth of the groove for the panel; set the height of the dado head to cut about $\frac{1}{2}$ inch into the tenon.
- With the stock on edge, utilize the fence and miter gauge to guide it into the blade.
- Repeat to cut the haunch on the other side of the tenon.
- For the rails of the front assembly, which has no panel, cut blind tenons, making the shoulders equal to the width of the notch you cut into the haunched tenons.

2 – How to outline the mortises in the stiles

- Mark the approximate locations of the mortises on each stile.

- Then utilize one of the rails you cut in step 1 to outline the length and width of the mortises.
- Start by holding the cheek of the tenon flush against the face of one of the stiles; ensure that the edge of the rail is aligned with the end of the stile.
- Outline the length of the tenon.
- To mark the mortise width, hold the edge of a tenon flush against the marked face of the stile and outline the cheeks of the tenon.
- Extend the lines along the face.
- Once all the mortises are outlined, chisel them out rather deeper than the tenon length, utilizing a mortise chisel.

3 – How to cut grooves for the panels

- On the rails and stiles, mark locations for the grooves that will hold the panel.
- You will need to make a groove in two sides of each rear stile, aligning the cuts with the mortises you cut in step 2.
- Then set up your table saw with a dado head the same width as the groove, typically $\frac{1}{4}$ inch.
- To cut the grooves in the rails, center the edge of a rail directly over the dado head and position the fence against the stock.
- Set the blade height to $\frac{1}{4}$ inch.
- Use a feather board, braced by a support board, to hold the work piece against the fence while the cut.
- To cut the grooves in the stiles, do not move the fence, but adjust the position of the feather board and support board.
- Feed the stock with a push stick.
- You can utilize the jig to cut blind tenons on the table saw.
- Adapt the dimensions suggested to customize the jig for your saw, if necessary.
- Cut the jig fence and back from $\frac{3}{4}$ inch plywood and saw a 45 degree bevel at one end of each board: the pieces should be wider than the height of your saw's rip fence.
- Fasten two pieces together face to face to fashion the back, then utilize countersunk screws to attach the fence and back in an L shape.

- Ensure the fasteners will not be in the blade's path when you utilize the jig.
- Then, cut the brace from solid stock, bevel its ends, and attach it flush with the top edges of the fence and back, forming a triangle.
- Make the clamp by face gluing two pieces of $\frac{3}{4}$ inch plywood.
- Use a hanger bolt, washer, and wing nut to attach the clamp to the jig back, leaving a gap amongst the edge of the clamp and the fence equal to the thickness of the stock you will use.
- Offset the bolt so the clamp can pivot eccentrically.
- You can drill supplementary holes in the jig back so you can shift the clamp to accommodate different stock thicknesses.
- Then, cut the runner from solid wood.
- When attached to the jig fence, the runner will straddle the saw fence, eliminating any wobble.
- For some models, you will have to mill a groove down the length of the runner to fit the rip fence.
- Lastly, cut a piece of clear plastic as a blade guard and screw it to the jig back flush with its front face.
- To utilize the jig, set the saw table in front of the blade with the runner and fence straddling the rip fence.
- Clamp the work piece in the jig and position the rip fence to align the cutting mark on the work piece with the blade.
- Feed the jig into the cutting edge.
- Your first utilize of the jig will develop a kerf in the back.
- Flip the work piece around and repeat to cut the other cheek.
- Eliminate the jig to cut the shoulders.

How to make a raised panel on the router table

1 – How to set the fence

- Start by cutting the panel to size.
- Test fit the rails and stiles of the frame, then measure the opening amongst them.
- Add $\frac{1}{2}$ inch to each of the dimensions to allow the beveled edges of the panel to rest in the grooves routed in the frame; this will leave $\frac{1}{4}$ inch on each side to allow for wood movement.
- Then fit a router with a panel-raising bit and mount the tool in a table.
- To ensure that the cutting depth is uniform, position the fence in line with the edge of the bit pilot.
- With the tool switched off, place a scrap board along the fence.
- Adjust the fence until the bit pilot turns as the board touches it.
- Set the router to make a shallow cut at first, typically $\frac{1}{4}$ inch.

2 – How to make the cut

- Lower the guard over the bit and turn on the router.
- To minimize tear out, cut the ends first, beveling the top and bottom of the panel.
- Feed the stock into the bit outside face down, keeping it butted against the fence.
- Repeat for the two sides.
- Test-fit the panel in the grooves you cut in the rails and stiles.
- If the panel sits less than $\frac{1}{4}$ inch deep, increase the cutting depth by $\frac{1}{16}$ inch and make another pass around the panel.

How to make a raised panel on the saw table

1 – How to bevel the ends of the panel

- Cut the panel to size, and then set the blade angle to yield the appropriate bevel.
- The usual "reveal," or beveled area of a $\frac{3}{4}$ inch thick panel is approximately 1 $\frac{1}{4}$ inches.
- For a $\frac{1}{4}$ inch wide groove, begin by marking a $\frac{1}{4}$ inch square at the bottom corner of the panel.
- Then draw a line from the front face of the panel through the inside corner of the square to a point on the bottom edge $\frac{1}{8}$ inch from the back face.
- Install a 6 inch wide auxiliary wood fence, and then adjust the angle of the blade and the position of the fence until the cutting edge aligns with the marked line.
- Then, raise the blade until one tooth protrudes beyond the front face of the panel.
- Clamp a guide block to the panel so it will ride along the top of the fence.
- Make a cut in one end of the panel, and test fit the cut in a groove.
- If the panel rests less than $\frac{1}{4}$ inch deep, move the fence a little closer to the blade and make another pass.
- Repeat the cut at the other end of the panel.

2 – How to bevel the sides

- Beveling the sides after you have beveled the end grain helps minimize tear out.
- Set the panel on edge and feed it into the blade, keeping the back flush against the fence.
- Turn the panel over to cut the remaining edge.
- To raise a panel on the table saw without adjusting the angle of the blade, utilize the shop-built jig.
- Screw the lip along the bottom edge of the angled fence; ensure that you position the screws where they will not interfere with the

blade.

- Prop the angled fence against the auxiliary fence at the same angle as the cutting line marked on a panel, utilizing a sliding bevel to transfer the angle.
- Cut triangular support so fit precisely amongst the two fences, and then fix them in place with screws.
- Countersink the fasteners so the panel will slide smoothly along the angled fence.
- To utilize the jig, position it on the saw table with the joint amongst the lip and the angled fence approximately 1/8 inch from the blade.
- Butt the table saw's rip fence against the jig's auxiliary fence, and screw the two together.
- Turn on the saw and crank up the blade slowly to cut a kerf through the lip.
- Then, seat the panel in the jig and adjust the height of the blade until a single tooth protrudes beyond the front of the panel.
- Make a test cut in a scrap board the same thickness as the panel and then confirm its fit in the groove; adjust the position of the fence or blade, if necessary.
- Then cut the panel, beveling the ends before sawing the sides.

How to assemble the frame and panel

1 – How to fit the panel in the frame

- Once you have raised the panel, you are now ready to glue up the frame and panel assemblies that provide the backs of the two cases required for a two pedestal desk.
- Start by test fitting the parts and make any final adjustments.
- If any of the joints are too tight, utilize a chisel to pare away some wood.
- Once you are satisfied with the fit, disassemble the frame and sand any exteriors that will be hard to reach once the assembly has been glued up.
- You should also decide which technique you will utilize to install a top; some of these techniques require boring pocket holes in the rails or routing grooves in the rails and stiles.

2 – How to glue it up

- Apply glue to the tenon cheeks.
- Do not insert any adhesive in the grooves; the panel must be free to move.
- Clamp the frame and panel utilizing bar clamps across the rails, protecting the stock with wood blocks the same width and thickness as the rails.
- Tighten each clamp in turn until a thin bead of glue squeezes out of the joints.

How to build a non raised frame and panel

1 – How to rout a rabbet around the frame

- Like dust frames, the panels of frame and panel desks can be made flat instead of raised.
- To build this type of assembly, you can follow all the steps for a raised panel frame and panel except for beveling the edges of the panel.
- An alternative to placing the flat panel in a groove is to assemble the frame with blind mortise and tenons, and rout a rabbet around the frame to receive the panel.
- To cut the rabbet, glue up the rails and stiles and secure the assembly to a work exterior.
- Install a 3/8 inch piloted rabbeting bit in your router.
- Set the depth of cut at least ¼ inch deeper than the thickness of your panel to leave room for decorative molding.
- Rout the rabbet around the inside edges of the frame, keeping the bit pilot pressed against the stock throughout the cut, then square the curves with a chisel.

2 – How to install the panel and decorative molding

- Cut a panel from veneered plywood to fit the rabbets.
- A solid-wood panel would split the frame, since the rabbets provide no room for wood movement.
- Spread some glue in the rabbet and set the panel in place. For the decorative molding, shape the edge of a ¼ inch thick board long enough to yield molding for the inside edges of your frame; ensure the board is wide enough to feed safely across the table saw or router table you utilize to shape the molding.
- Rip the molding from the board into ¼ inch-square pieces.
- Then cut four pieces to fit the inside the frame, mitering the ends.
- Glue the top and bottom strips of molding to the frame first, positioning them to hold the panel in place.
- To clamp the molding, utilize thin strips rather longer than the gap amongst the molding pieces.

3 – How to install molding along the panel sides

- Once the glue securing the top and bottom molding strips has cured, glue the molding along the sides of the panel.
- Again, utilize clamping strips to hold the molding in place.

How to build a frame and panel case

1 – How to glue up the front assembly

- To assemble a frame-and-panel pedestal for a desk, begin by gluing up the front frame.
- For the desk, this frame consists of top and bottom rails, two stiles, and a series of drawer rails joined to the stiles with twin mortise and tenons.
- Apply glue to all the contacting exteriors of the joints and assemble the frame.
- Install a bar clamp across each of the rails, alternating amongst the top and bottom of the assembly where possible.
- To distribute clamping pressure and protect the stock, utilize two clamping strips.
- Tighten the clamps a little at a time, continuing until glue squeezes out of the joints.

2 – How to assemble the pedestal

- To complete the pedestal, build side assemblies to fit amongst the front and rear assemblies.
- Each side assembly needs just a panel and two rails, since it will share stiles with the front and rear assemblies.
- For a double-pedestal desk, the top rail of the assembly facing the second pedestal should be wider than the height of the central drawer amongst the two pedestals.
- Once you have prepared all the parts, test fit them, then sand their inside faces.
- Apply glue to all the joints-with the exclusion the panel grooves-and assemble the pedestal.
- Clamp the pedestal with bar clamps spanning the side rails; utilize wood pads to protect the stiles.

3 - Checking for square

- Measure the diagonals amongst opposite corners of the pedestal

immediately after tightening the clamps.

- They should be equal; if not, the pedestal is out-of-square.
- To correct the issue, install a bar clamp across the longer of the two diagonals.
- Tighten this clamp a little at a time, measuring as you go until the two diagonals are equal.

How to install the bottom

1 – How to install ledger strips

- To install a bottom utilizing ledger strips, cut four 1 inch-square wood strips to fit along the rails at the bottom of the case.
- The ends of the strips should butt against the stiles.
- Bore two sets of countersunk holes in each strip: one centered along one edge, for screwing the strip to the rail, and another along an adjacent edge for attaching the bottom panel.
- Stagger the holes so the fasteners will not contact each other.
- With the pedestal upside-down, position a ledger strip on the inside exterior of a bottom rail about 1 inch from its top edge.
- Mark the positions of the screw holes with an awl and bore pilot holes.
- Utilizing clamps to hold the strip in position, screw the strip in place.
- Repeat for the other ledger strips.

2 – How to install the bottom

- Cut a bottom panel to fit the case, notching its curves to fit around the stiles.
- To mount the panel, set the pedestal on it's back.
- Holding the panel flush against the strips with one hand, mark the screw holes with an awl and bore pilot holes.
- Then screw the bottom in position.

How to joint desk pedestals

1 – How to plan the joinery

- Once both desk pedestals are glued up, you are ready to join them.
- At the back of the desk, a rear connecting rail is attached to the stiles of the pedestals with blind mortise and tenons; this rail provides structural support and hides the back of the central drawer.
- At the front, a connecting rail, which provides support for the top, is joined to the stiles with dovetailed half lap joints.
- Directly below this rail is a support board for the central drawer.
- It is connected to the stiles with twin mortise and tenons.

2 – How to attach the connecting rails and drawer support

- Test fit the rear connecting rail and the drawer support in the pedestals.
- For the front connecting rail, cut a dovetailed half lap at each end with a dovetail saw.
- Use the half laps to outline the mating mortises at the top ends of the stiles, then cut and chisel them out.
- Test fit the rail in the mortises, paring the half laps if necessary to ensure a tight fit.

3 – How to glue up the desk

- Apply glue to all the joints amongst the connecting rails and drawer support and the pedestals and assemble the desk.
- Clamp the unit across the back with a long pipe clamp, utilizing wood pads to protect the stock.
- Install a second pipe clamp along the drawer support at the front of the desk.
- Confirm the opening amongst the pedestals for square by measuring across the curves.
- Install a third clamp if required.

Chapter 20 How to design tables

A crucial part of building a piece of furniture is deciding on its final dimensions. A desk that is too high or low will be uncomfortable; a tabletop that crowds its diners will make mealtime an aggravating involvement.

Once you have chosen a particular style from the gallery of tables and desk, it is time to size its parts. Standard dimensions for a wide range of traditional and modern table and desk styles are provided below.

Dining tables should provide 24 inches in width for each diner. Allow at least 12 inches from the table edge to the center for each place setting; an supplementary 4 to 6 inches will provide space for serving dishes.

To allow adequate leg room, leave about 7 ½ inches amongst the chair seat and the underside of the top, and at least 2 feet amongst the floor and the bottom of the table or desk rail.

Recall, Nevertheless, that these figures are guidelines; furniture should fit those utalizing it. A table or a desk also should fit into its environment. For desks and dining tables, Recall to allow for the height of the accompanying chairs. Bedside tables should not rise more than 6 inches above the bed.

Hundreds of table and desk styles have evolved throughout the ages, each with its own specific purpose. The butler's table, For instance, also serves as a serving tray.

The secretary combines a bookcase, a desk, and a chest of drawers, supplying ample storage space for books, papers, and other items, and a writing exterior that can be folded up out of the way when not in use.

Standard Table and desk dimensions

Tables

- *Bedside (night table) - Height: 24-30 inches, Length: 18 inches, Width: 18 inches, Diameter: n/a*
- *Butler's table - Height: 24-36 inches, Length: 36-48 inches, Width: 20 inches, Diameter: n/a*
- *Butterfly table - Height: Depends on usage, Length: Depends on usage, Width: Depends on usage, Diameter: n/a*
- *Candle stand - Height: 25-31 inches, Length: n/a, Width: n/a, Diameter: 12-17 inches*
- *Card table - Height: 25-29 inches, Length: 28-36 inches, Width: 28-36 inches, Diameter: n/a*
- *Coffee table - Height: 12-22 inches, Length: Depends on usage, Width: 20 inches, Diameter: n/a*
- *Conference table - Height: 30 inches, Length: Depends on usage, Width: Depends on usage, Diameter: n/a*
- *Console table - Height: 30 inches, Length: 36-72 inches, Width: 16-20 inches, Diameter: n/a*
- *Dressing table - Height: 29-30 inches, Length: 40-48 inches, Width: 18-22 inches, Diameter: n/a*
- *Drop-leaf table - Height: Depends on usage, Length: Depends on usage, Width: Depends on usage, Diameter: n/a*
- *Extension dining table - Height: 29-31 inches, Length: Depends on usage, Width: 36-42 inches, Diameter: n/a*
- *Gateleg table - Height: 29-30 inches, Length: Depends on usage, Width: Depends on usage, Diameter: Depends on usage*
- *Library table - Height: 30 inches, Length: 60-84 inches, Width: 24-36 inches, Diameter: n/a*
- *Occasional table - Height: 27-29 inches, Length: 24-28 inches, Width: 24-28 inches, Diameter: 24-28*
- *Round dining table - Height: 29-31 inches, Length: n/a, Width: n/a, Diameter: 40 inches at least*
- *Tilt-top table - Height: 26-28 inches, Length: n/a, Width: n/a, Diameter: 24-26 inches*
- *Trestle table - Height: 29-31 inches, Length: 48-120 inches, Width: 30 inches, Diameter: n/a*

Desks

- *Computer desk - Height: 20-26 inches, Length: 48-50 inches, Width: 24-30 inches, Diameter: n/a*
- *Executive desk - Height: 29-30 inches, Length: 72-84 inches, Width: 36-42 inches, Diameter: n/a*
- *Office desk - Height: 29 inches, Length: 60 inches, Width: 30 inches, Diameter: n/a*
- *Pedestal desk - Height: 30 inches, Length: 30-42 inches, Width: 18-22 inches, Diameter: n/a*
- *Secretarial desk - Height: 30 inches, Length: 60-66 inches, Width: 30-32 inches, Diameter: n/a*
- *Secretary desk - Height: 74-86 inches, Length: 30-44 inches, Width: 18-22 inches, Diameter: n/a*
- *Typewriter stand - Height: 30 inches, Length: 30 inches, Width: 18 inches, Diameter: n/a*

Chapter 21 How to design legs and rails

Legs and rails are the structural heart of most tables and desks. The furniture legs provide vertical support, and the rails connect and brace the legs while also supporting the top and framing the drawer assembly.

Strength and beauty must be in harmony here: The shape and proportion of the legs and rails must complement other elements of the piece of furniture, balancing the weight of the top and the size of the drawers. For instance,

The following chapter demonstrates the techniques for making numerous of the most common types of table and desk legs, including tapered, cabriole, turned, pedestal, and octagonal pieces.

This is followed by detailed instructions for joining legs to rails. Making the legs is typically the first step in constructing a table or desk. Since most legs require denser stock than is commonly obtainable, you typically must face-glue thinner stock into a blank of appropriate size.

Ensure the length of the blank is proportional to the intended height of the table or desk, and that it will be robust enough without appearing too bulky. Also review the design and planned utilization of the piece before choosing an appropriate leg style.

The delicate cabriole leg has been a popular feature of high-quality furniture for more than two centuries. Straightforward to cut on the band saw, the cabriole is intended to suggest the leg of a leaping animal.

Tapered legs can be cut on a jointer or table saw and are suitable for a wide range of tables and desks. They are a straightforward alternative to turned legs. A table is just as sturdy as the joinery used for the leg-to-rail assembly. Traditional joints, such as the mortise and tenon or dowel joint are reliable.

If the piece will be moved often, commercial or shop-made hardware that allows the legs to be eliminated may be your best option. In designing your table or desk, take into account the technique you will utilize to attach the top to the rails.

If, for instance, you plan to utilize wood buttons, you will need to cut the grooves in the rails before they are fastened to the legs. A lower rail, or stretcher, can be added to any table for extra strength or decorative effect; gateleg tables may require these bottom rails to serve as anchoring points for

any extra legs.

How to design tapered legs

1 – How to set up and starting the cut

- You can taper legs rapidly and accurately on a jointer.
- Start by outlining the dimensions of the taper on the bottom of the leg blank with a cutting gauge.
- Then mark lines on the four faces of the stock to indicate where the taper will begin.
- Install a clamp to hold the guard out of the way while the operation.
- Set the depth of cut for x inch and, holding the blank against the fence, align the taper start line with the front of the out feed table.
- Butt a stop block against the bottom of the leg and clamp it to the in feed table.
- To start each pass, cautiously lower the blank onto the cutter head while holding it firmly against the fence and the stop block.
- Ensure both hands are over the in feed side of the table.

2 - Jointing the taper

- Feed the leg across the cutter head with a push stick, pushing down on the trailing end of the stock while pressing it flush against the fence.
- Keep your left hand away from the cutter head.
- Make as numerous passes as necessary until you have trimmed the stock to the taper outline, then repeat the procedure to shape the remaining faces.
- Make the same number of passes on each side.

How to joint the stopped taper

- Mark lines on all faces of the leg blank to indicate where the tapering will begin and end.
- Install a clamp on your jointer's in feed table to hold the guard out of the way.
- Set a 1/8 inch depth of cut, then butt the blank against the fence with the taper line about $\frac{3}{4}$ inch in front of the edge of the out feed table.
- The extra $\frac{3}{4}$ inch will compensate for the fact that, as the in feed table is lowered later, it will also slide back.
- Butt a stop block against the foot of the blank and clamp it to the in feed table.
- Then align the taper end line with the back end of the in feed table.
- Butt a second stop block against the top end of the blank and clamp it to the out feed table.
- To make the first pass, lower the work piece onto the knives, keeping it flush against the fence and stop block on the in feed table.
- Feed the work piece utilizing a push stick; utilize your left hand to press the blank against the fence.
- Keep both hands well clear of the cutter head.
- Make one pass on each face, then lower the in feed table 1/8 inch and repeat the procedure on all four sides.
- Continue, increasing the cutting depth with each pass until the taper is completed

Jig for two sided tapers

- Tapering legs on a table saw can be done simply with the right jig.
- The one I will discuss is made from $\frac{3}{4}$ inch plywood, some solid wood, and two toggle clamps.
- It is sturdier than numerous commercial models; the clamps ensure that the stock is held firmly in place while the cut is being made.
- To assemble the jig, set the saw blade to its maximum cutting height, butt one side of the jig base against the blade, and position the rip fence against the other side of the base.
- Lower the blade and mark a cutting line for the taper on one side of your leg blank, then set it on the base, aligning the mark with one edge of the jig.
- Hold the work piece securely and butt the plywood guide bar against it.
- Press the lip snugly against the end of the blank.
- Screw the guide bar to the base and the solid wood shim to the bar, making certain that their edges are aligned.
- Attach the toggle clamps to the shim.
- Clamp down to secure the blank to the jig with the taper mark aligned with the edge of the base.
- Screw the handle to the base at least 6 inches away from the side that will pass by the blade.
- To cut the first taper, clamp a feather board and support board to the saw table, making sure they will not interfere with the blade.
- The feather board should press just on the jig base, not on the work piece.
- Set the blade height and slide the jig and leg blank across the table, making sure that neither hand is in line with the blade.
- To cut the second taper on an adjacent side of the blank, repeat the pass with the two untapered sides of the blank against the jig base and guide bar.

How to design cabriole legs

1 - Designing the leg

- For a template, cut a piece of stiff cardboard or hardboard to the same length and width as your leg blanks.
- Begin drawing the leg by outlining the post block.
- Make its length equal to the width of the rail that will be attached to it; the post block should be wide enough to accept the rail tenons.
- Then, sketch the toe and the front of the leg from the toe to the ankle utilizing a French curve; at its narrowest point, the ankle should measure about two fifths of the stock width.
- Move on to the knee, sketching a gentle curve from the post block to the front edge of the template about 3 to 4 inches below the block.
- Then join the knee to the ankle with a rather straight line.
- Complete the outline at the back of the leg, connecting the bottom of the leg with the back of the ankle, and then sketching a curve from the ankle to the bottom of the post block.
- You may need to redraw the curves several times until you are satisfied with the design.

2 - Transferring the design

- Cut out your template on a band saw, and then sand the edges to the marked outline.
- To trace the outline on the leg blank, place the template flat on one of the inside faces of the blank, making sure that the ends of the template and the blank are aligned and that the back of the post block is flush with the inside edge of the blank.
- Trace along the edges of the template.
- Turn the blank over and repeat the procedure on the other inside face.
- At this point, some woodworkers prefer to cut mortises or drill holes for the leg-to-rail joinery.
- It is easier to clamp and cut joints on a rectangular leg blank than

on a leg with pronounced curves.

- Other woodworkers cut the leg first and then do the joinery.

3 – How to cut out the leg

- Set the les blank on the band saw table with one of the outlines facing up and the toe of the leg pointing away from you.
- Aligning the saw blade just to the waste side of the marked line for the back of the leg feed the stock into the cutting edge.
- Turn off the saw about halfway through the cut and eliminate the blank.
- Then cut along the same line from the opposite end.
- To avoid detaching the waste piece from the blank and losing the marked outline on the adjacent face, stop the cut about $\frac{1}{2}$ inch from the first kerf, leaving a short bridge amongst the two cuts.
- Retract the work piece, and then cut along the line for the front of the leg, again leaving bridges.
- Turn the blank and saw along the marked lines on the adjacent side.
- This time, complete the cut, letting the waste fall away.

4 – How to cut the bridges

- Turn off the saw and rotate the blank so that the first side you cut faces up.
- Slide the blank forward to feed the blade into the kerf at the front of the leg.
- Turn on the machine and cut through the bridge to release the waste piece.
- Then cut through the bridge amongst the kerfs at the back of the leg.

5 - Shaping and smoothing the leg

- To finish shaping the cabriole leg and eliminate blemishes left by the band saw blade, smooth its exteriors with a spoke shave, followed by a rasp and sandpaper.

- Begin by fixing a bar clamp in your bench vise, and then secure the leg in the clamp.
- Holding a spoke shave with both hands at the top of a curved edge of the leg, pull the tool slowly toward you, cutting with the grain.
- Repeat until the exterior is smooth.
- Turn the leg in the bar clamp to clean up the other edges.
- Use a rasp to smooth an area that the spoke shave cannot reach.
- This tool works best when pushed diagonally across the grain.
- Finish the job with sandpaper, utilizing progressively finer grits until the exterior is smooth.

How to design turned legs

1 – How to define the pommel

- To turn a leg on a lathe, start by separating the pommel from the cylindrical section.
- The cylindrical section is then turned (step 2) and, Lastly, the beads and hollows are added (step 3).
- Begin by marking the pommel on the leg blank, then mount the blank on the lathe and move the tool rest as close to the work piece as possible without touching it; the pommel should be long enough to accommodate the leg to rail joinery technique you will use.
- Then, utilize a skew chisel to cut a V-fashioned notch at the marked pommel line.
- Bracing the blade against the tool rest, begin with the cutting edge angled rather to one side so the long point of the tip cuts into the blank.
- This will define one side of the V.
- Now, angle the blade to the other side to define the other side of the V notch.
- Continue angling the blade from side to side until you reach the desired depth.
- As much as possible, keep the bevel of the blade rubbing against the stock at all times.

2 – How to turn the cylinder

- Use a roughing-out gouge to round the curves of the blank below the pommel.
- With the tip of the gouge tilted up against the rotating blank, gradually raise the handle until the bevel under the tip is rubbing against the stock and the cutting edge is slicing into the wood.
- Work from below the pommel toward the bottom of the leg.
- Keep the tool at a right angle to the blank throughout the cut.
- Continue until the blank is cylindrical and smooth.

3 - Adding beads and hollows

- To form beads, work with a skew chisel and the same technique used to define the pommel.
- Starting each cut with the tool almost horizontal, raise the handle until the blade slices into the stock.
- Cut one side of the bead at a time by tilting the cutting edge first to one side and then the other.
- For the hollows, utilize a spindle gauge.
- Start each cut at one edge of the hollow with the blade on edge so that its concave side is facing the opposite edge of the hollow.
- Raise the handle so the tip begins slicing into the stock.
- Then, sweep the tool toward the hollow's opposite edge, rolling the blade so that, at the center of the hollow, the concave side of the blade is facing up.
- Eliminate the gouge and repeat the cut from the opposite edge of the hollow, with the concave side of the blade facing toward the hollow.
- Continue sweeping and rolling the blade from side to side, always working downhill, until the hollow is symmetrical and smooth.

Sawing the leg on the band saw

- Cut a dovetail on the top end of your leg blank, utilizing either the table saw or a router table.
- Then, outline the leg on your blank; utilize a pencil and a French curve as you would for a cabriole leg.
- There are three absolute rules for designing a pedestal leg:
- The grain should follow the slope of the leg, the top and bottom ends must be perpendicular to each other, and the spread of the legs must be less than the diameter of the table top.
- Once you are satisfied with the design, cut the first leg on the band saw and utilize it as a template for the others.
- Keep a copy of the template for future ventures.

How to cut the leg on the table saw

- To set up this operation, unplug the saw, crank the blade to its highest setting, and adjust the cutting angle to 45 degree.
- The rip fence should be situated so that the blade is tilted away from it.
- Lay one face of the leg blank on the blade with a corner resting on the saw table, then butt the fence against the stock and lock it in place.
- To make the first cut, butt the stock face-down against the rip fence a few inches in front of the blade.
- Adjust the cutting height until one tooth just protrudes beyond the face of the work piece.
- Feed the blank into the blade, straddling the fence with your hand.
- Rotate the leg 90 degree clockwise and repeat the cut on the adjacent face.
- Continue in this manner until the sides are cut.

Utilizing a table saw

- To cut a straight groove for inlay, utilize a table saw with a dado head the same width as the inlay.
- If you are working with thick shop-made inlay, set the cutting height to rather less than the thickness of the inlay; for commercial inlay, set the cutting height to its exact thickness.
- Make a cut in a scrap board, test the fit, and adjust the width and cutting height of the blades, if necessary.
- Then, mark a line for the groove on the leading end of the leg and align it with the dado head.
- Butt the rip fence against the stock, and then feed it across the blades.

Utilizing a router

- To make a groove that requires more than one straight cut at different angles, utilize a router with a commercial edge guide.
- Secure the leg to a work exterior, then fit the router with a straight bit the same width as the inlay and set the cutting depth.
- Recall, the groove should be rather shallow for shop-made inlay, but full-depth for commercial inlay.
- Outline the groove on the leg, align the bit over one of the lines that run along the grain, and butt the edge guide's fence against the stock.
- Gripping the router firmly, cut the groove; Recall to move the tool against the direction of bit rotation.
- Repeat to cut the other grooves.
- For the short cuts against the grain, clamp a wooden edge guide across the leg.
- Lastly, square the curves with a chisel.

Setting the inlay in the groove

- Cut the inlay to length to fit the groove.
- If you are utilizing shop-made inlay, utilize a table saw or a backsaw in a miter box; for commercial inlay, utilize a wood chisel.
- To install inlay in the four-sided groove, make miter cuts at the ends of the inlay pieces.
- It is easiest to cut and dry fit one piece at a time, making sure you align the miter cuts with the curves of the grooves.
- With commercial inlay marquetry, try to match the pattern at the curves to form one constant design.
- Once all the pieces are cut to size, spread a thin layer of glue in the groove and on the mitered ends of the inlay.
- Insert one strip at a time.
- While the glue dries, secure the inlay with strips of masking tape.

Routing edge detail

- Secure the leg to a work exterior.
- Mark lines on the leg for the beginning and end of the cut, then install a decorative bit in your router.
- A piloted quarter-round bit will rout a raised bead along the front curves of the leg.
- Set a cutting depth appropriate to the profile you want to make, then align the bit with the start line.
- Holding the tool with both hands, guide the bit along the corner of the leg against the direction of bit rotation.
- Keep the base plate flat on the top exterior of the leg and the bit pilot pressed against the stock throughout the operation.
- Stop when you reach the end line, reposition the leg on the work exterior, and make a second pass, riding the base plate on the adjacent face of the leg.
- This is typically done just on the leg's outside corner, but the other curves can also be routed depending on the leg design.

Joinery techniques

1 - Marking the location of the wedge

- Cut a four shouldered tenon long enough to extend beyond the leg by at least 2 inches; this will provide sufficient stock to resist being split by the wedge.
- Cut a through mortise to accommodate the tenon and assemble the joint.
- Then, holding the pieces together on a work exterior, mark a line on the top of the cheek where the tenon emerges from the mortise.

2 - Drilling the hole for the wedge

- Disassemble the joint and make a drilling mark 1/16 inch on the shoulder side of the scribed line; this will ensure a tight fit when the wedge is driven into place.
- Set a mortise gauge to one-third the thickness of the tenon and utilize the gauge to outline the hole in the middle third of the top cheek, bordering on your mark.
- Utilizing a bit rather smaller in diameter than the outline, bore the hole through the tenon on the drill press.

3 - Angling the wedge hole

- Utilizing a mortise chisel, enlarge and square the hole you drilled to accommodate the wedge.
- Holding the chisel at a 10 degree angle away from the tenon shoulders, cut a tapered slot, as indicated by the dotted lines.
- Then chop out the waste, holding the chisel with the bevel facing the waste.

4 - Inserting the tusk

- Cut an angled hardwood wedge, called a tusk, that is tapered to fit the slot you chopped in step 3; its length can be up to twice the tenon width.

- To assemble the joint, slide the tenon into the mortise and strike the wedge firmly with a mallet until the joint is tight.
- Do not utilize glue, as this joint is intended to be disassembled.

Dowel joints techniques

1 - Locating and boring dowel holes in the rails

- Start by marking the location of the dowel holes. Holding one of the rails end-up, set a cutting gauge to one-half the thickness of the stock and scribe a line across the end of the board.
- With the gauge at a rather wider setting, scribe two lines that intersect with the first line on the end of the rail.
- To avoid splitting the stock, utilize grooved dowels no more than one-half the thickness of the rails.
- Fit a drill press or an electric drill with a bit the same diameter as the dowels and bore a hole at each location point; the depth should be rather more than one-half the length of the dowels.
- Use the same technique to bore the dowel holes at the opposite end of the rail and in the other rails.

2 - Pinpointing mating dowel holes

- Insert dowel centers in the holes.
- Then align the top of the rail with the top of the leg, and swing the rail up so that its outside face is $\frac{1}{4}$ to $\frac{1}{8}$ inch inside the edge of the leg.
- A pencil mark like will help align the rail.
- Tap the other end of the rail with a wooden mallet.
- The pointed ends of the dowel centers will punch impressions on the leg, providing starting points for boring the mating dowel holes.
- Repeat for the other rails and less.

3 - Boring the mating dowel holes

- Bore the holes in the legs to the same depth as those in the rails- rather more than one-half the length of the dowels.
- If you are drilling into a tapered leg on a drill press, be sure to keep the square part of the leg flat on the machine's table.

4 - Assembling the legs and rails

- Spread a little glue on the exteriors of the legs and rails that will contact each other, then dab a small amount of adhesive in the bottom of the dowel holes with a small wood scrap.
- Avoid spreading glue directly on the dowels; they absorb moisture rapidly and will swell, making them hard to fit into the holes.
- Insert the dowels into the legs, and then tap the rail lightly with a mallet to seat the shoulder.
- Be cautious about utilizing too much force, which can cause a leg to split.
- Fit each end of the rail onto a leg and hold the joint together with a bar clamp, protecting the legs with wood pads.
- Align the bar of the clamp with the rail, and then tighten it until a bead of glue squeezes out of the joint.

Hand cut blind mortise and tenons techniques

1 – How to cut the tenon cheeks

- Outline the tenons on the rails, marking a shoulder line all around the ends so that the length of the tenons will be no more than three-quarters the thickness of the leg.
- Secure one of the rails end-up in a vise.
- Cut along the lines on the end of the rail with a backsaw; tilt the saw forward and cut to the shoulder line of the tenon.
- Then complete the cut with the saw level.

2 – How to cut the tenon shoulders

- To eliminate the waste from the tenon cheeks, clamp the rail face-up on a work exterior, protecting the stock with a wood pad.
- Cut along the shoulder line on the face of the rail; turn over the stock and repeat the operation on the other side.
- To cut away the waste on the edges of the tenon, secure the rail end-up in a vise and saw to the shoulder line on both edges of the rail.
- Lastly, clamp the rail edge-up and cut through the shoulder lines on both edges of the rail.
- Repeat steps 1 and 2 to cut the tenon on the other end of the rail and at both ends of the remaining rails.

3 - Outlining the mortises

- Mark the mortise outline on each leg in two steps, utilizing one of the rail tenons as a guide.
- First, hold the cheek of the tenon flush against the leg, with the top of the rail aligned with the end of the leg.
- Draw a pencil along the edges of the tenon to outline the length of the mortise, and then utilize a try square to extend the lines across the leg.
- To mark the width of the mortise, hold the edge of the tenon centered flush against the leg and mark along each cheek.

- With a try square, extend the marks along the leg until the two outlines intersect.
- Repeat the procedure on the adjacent face of the leg.

4 - Chiseling the mortises

- For each mortise, clamp the leg to a work exterior, protecting the stock with a wood pad.
- Then, starting at one end of the outline, hold a mortise chisel square to the face of the leg and strike it with a wooden mallet.
- Use a chisel the same width as the tenon and be sure that the beveled side of the blade is facing the waste.
- Make another cut 1/8 inch from the first.
- Continue until you reach the other end of the outline, levering out the waste to a depth that rather exceeds the length of the tenon.
- Test-fit the tenon and widen or deepen the mortise as required.
- Repeat to cut the remaining mortises.
- Then spread glue lightly in the mortises and on the cheeks of the tenons.
- Fit the legs and rails together, and then close up the joints with the same clamping setup used for the dowel joint.

How to assemble the legs, column and rail for a tripod table

1 - Turning the tenon on the column

- Start by turning the rail tenon at the top of the column.
- Then rout the dovetail sockets for the legs at the column's bottom.
- Then, cut the dovetails in the legs (steps 3 and 4) and assemble the pieces (step 5).
- Mount the column blank on your lathe and turn it into a cylinder, leaving a lip and enough stock near the bottom for the leg sockets.
- To turn the tenon, utilize a parting tool, moving the blade from side to side.
- The length of the tenon should be about one-half the thickness of the mating rail.
- Its diameter should be at least $\frac{3}{4}$ inch and match that of the bit you will utilize to drill the mortise in the rail.

2 - Routing the dovetail sockets

- Unplug your lathe and turn the column end-for-end to cut the sockets, utilizing a router and a shop-made jig consisting of a $\frac{3}{4}$ inch plywood box clamped to the lathe bed.
- Make the box as wide as the router base plate.
- Attach the two runners so the router bit will cut the sockets with its base plate sitting on them.
- Then, mark the location of the three sockets on the column; they should be 120 degree apart.
- Also mark the upper ends of the sockets, about 3 inches from the bottom of the column.
- To help align the cuts, transfer the socket marks from the column to the lathe faceplate.
- Now, rotate the column by hand until one of the marks on the faceplate is vertical and clamp the drive shaft with a hand screw.
- Cut each socket in two passes, first utilizing a straight bit, then a dovetail bit.
- Adjust the router's cutting depth, align the bit with the socket end mark, butt a stop block against the router base plate, and screw the

block to the jig.

- Holding the router in both hands, plunge the bit into the column, starting at the bottom, and guide the tool along the runners until the base plate contacts the stop block.
- Repeat with the dovetail bit.
- To cut the second and third sockets, rotate the column so the socket mark for each cut is vertical.

3 - Cutting the dovetails

- The dovetails in the legs are cut in two steps:
- The first cut is made on the table saw, and the second by hand.
- It is easiest to cut the dovetails on leg blanks before shaping the legs.
- Adjust your table saw's blade angle to match that of the sockets you cut in step 2.
- Set the cutting height to rather less than the depth of the sockets.
- Outline the dovetails on the edge of one leg blank and, holding the blank on end on the saw table, align a cutting mark with the blade.
- Butt the rip fence against the stock and lock it in place.
- Clamp a shimmed feather board to the table to support the blanks.
- Also clamp a guide block to the blank; the block will ride along the top of the fence, helping to guide the work piece.
- To form the dovetail, make a pass to cut one cheek, and then rotate the work piece and feed the opposite face along the fence to saw the other.
- Once both cheeks of the first dovetail have been cut, confirm them against a socket in the column.
- If necessary, adjust the blade angle or height or the cutting width and make another set of passes.
- Repeat for the other dovetails.

4 – How to cut the angled shoulders

- The shoulders of the leg dovetails must be cut at an angle so they lie flush against the column.

- Once the dovetail cheeks are all cut, clamp a blank to a work exterior with the cheek cuts extending off the table.
- Then utilize a backsaw to cut the shoulders to roughly match the curvature of the column.
- Test fit the dovetail in its socket and trim the shoulders, if necessary, until you get a suitable fit.
- Repeat for the remaining dovetails.

5 - Fastening the legs to the column

- Once all the dovetails fit in their sockets, trim off the top $\frac{3}{4}$ inch of each dovetail.
- This will hide the tops of the dovetails from view when they are pushed all the way into their sockets.
- Now you are ready to cut out the legs and attach them to the column.
- Spread glue equally on the dovetails and in the sockets.
- Then, holding the column upside-down on the floor, slide the legs into place and tap them into final position with a wooden mallet.
- To strengthen the assembly, add a three armed plate cut from sheet metal.
- Then, cut the rail that will connect the column to the table top.
- Bore a mortise in the center of the rail to accept the tenon at the top of the column.
- Use a router fitted with a rounding-over or chamfering bit to shape the bottom edge of the rail all the way around.
- Lastly, stand the table upright, spread glue on the tenon and in the mortise, fit the rail over the tenon, and screw the rail in place.

How to glue up the leg assembly for a pedestal table

1 – How to prepare the column for the legs

- Mark a line across the column near the bottom to define the square section that will be joined to the legs; the area should be as long as the width of the legs.
- Install a dado head on your table saw and set the cutting height at

rough ½ inch.

- Utilizing the miter gauge, make several passes across the column to eliminate the waste from all four sides of the column.

2 - Cutting the dovetail sockets

- Plow a dovetail socket on each side of the column on the router table.
- Install a straight bit in your router and mount the tool in a table.
- Mark a line for the sockets down the center of each side, align a socket mark with the bit, butt guide boards against the stock, and clamp the boards to the table.
- Feed the column across the table to cut the first socket, stopping the cut when the bit reaches the end of the square section.
- Leave the column in place, turn off the tool, and clamp a hand screw as a stop block against the end of the column.
- Repeat the cut on the other sides of the column, stopping when the stock contacts the hand screw.
- Complete the task with a second pass on each side utilizing a dovetail bit.

3 - Preparing the top of the column

- Once the dovetails are cut, turn the column on a lathe, leaving a square section at the top to accommodate the rails and a lip just above the bottom square section to conceal the tops of the legs.
- The rails will fit into two intersecting mortises cut in the column's square section.
- Mark cutting lines for the mortises down the center of each side of the column; the mortise width should be one-half the thickness of the rails.
- Set the saw blade height to the width of the rails less the edge recess.
- To feed the column safely, make a jig to hold it upright.
- Take a large push stick and screw a piece of wood to the side, forming an L.
- With the leg resting snugly in the L, align the cutting mark with

- the blade and lock the rip fence against the face of the push stick.
- Lay a spacer on top of the fence and screw it to the push stick; screw a guide board to the spacer so the jig forms a channel over the fence.
- Confirm the alignment, clamp the leg in place, and make a sequence of cuts until the mortise is wide enough.
- Repeat all cuts on each face to ensure that the mortises are perfectly centered.

4 - Cutting the dovetails on the legs

- Install a dovetail bit in your router and mount the tool in a table.
- Set the cutting depth to make the dovetails rather shorter than the depth of the dovetail sockets you cut in step 1.
- Position the fence so that about one-half of the cutter ventures beyond its face.
- With a feather board clamped to the table to support the work piece, feed a leg blank on end across the table, pressing it against the fence.
- Turn the blank end-for-end and repeat to complete the dovetail.
- Test fit the joint and adjust the fence and make supplementary cuts, if necessary.
- Repeat for the other leg blanks.

5 - Joining the legs to the column

- Cut out the legs on a band saw, and then notch the top end of the dovetails so that they stop short of the socket end.
- This will conceal the joints amongst the legs and column.
- Spread glue on the dovetails and in the sockets and slide the dovetails into place, tapping them with a mallet if necessary.
- For supplementary strength, you can make a four-armed bracket out of sheet metal to fit under the column and legs, and screw it in place.

6 – How to prepare the rails

- To allow the rails to fit the grooves in the column, cut recesses in the middle of both faces of the rails.
- Install a dado head on your table saw and set the cutting depth to about one-quarter the rail thickness.
- Screw an extension to the miter gauge.
- Make test cuts in a piece of scrap to be sure that the rails will fit snugly in the mortises.
- Mark the shoulders of the recesses on one rail so they are as long as the width of the square section at the top of the column.
- Align a mark with the dado head and clamp a stop block to the extension, flush against the rail.
- Feed the rail with the miter gauge, pressing the stock against the stop block.
- Flip the piece to cut a shoulder on the other face, then rotate the piece and cut the shoulders at the other ends of the recesses.
- Repeat on the other rail, then eliminate the stop block and eliminate the remaining waste.

7 - Joining the rails to the column

- To conceal the mortises once the rails are in place, cut a ½ inch-deep recess into the bottom edge of each rail, along the length of the recess in the face.
- Then, notch the middle of the edges.
- This can be done with the dado head; the width should equal the thickness of the lapped section of the rails.
- Adjust the blade height to cut halfway through the rail, and then saw an edge half-lap in the bottom edge of one rail and the top edge of the other, making sure the notches are centered amongst the shoulders.
- Adjust the blade height for the second rail to account for the edge recess.
- Once both edge half-laps are cut, round the ends of the rails on the band saw, spread some glue on the contacting exteriors of the column and rails, set the column bottom end up on the floor, and fit the rails in place.

How to utilize commercial leg hardware

1 – How to prepare the rails

- Commercial hardware that connects legs and rails should be installed following the manufacturer's instructions.
- To utilize the hardware, test assemble the leg, rails, and mounting plate, then mark the location of the plate flanges on the rails.
- To cut the slots for the flanges, align each mark with the blade, then butt the rip fence against the rail.
- Set the blade height to the length of the flange, adding 1/16 inch for clearance.
- Feed the rail into the blade with the miter gauge.
- Repeat for the other rail.
- Slip the flanges into the slots and mark the screw holes on the stock.
- Bore pilot holes and screw the mounting plate to the rails.

2 - Notching the leg for the mounting plate

- A notch must be cut at the top of each leg to accommodate the mounting plate.
- Stand the leg up and hold the rail and plate assembly on top of it, aligning the ends of the rails with adjacent sides of the leg.
- Mark a 45 degree diagonal line across the top of the leg along the mounting plate.
- Then, align the top of the plate with the top of the leg and mark a line along the bottom edge of the plate across the inside corner of the leg, adding 1/16 inch for clearance.
- To cut the notch, set the leg on a band saw and tilt the table to 45 degree to align the blade with the diagonal line.
- Butt a board against the leg and clamp it to the table as a rip fence.
- Feed the leg into the blade, and then clamp a stop block in place to help with repeat cuts.
- Complete the notch utilizing a handsaw.

3 - Preparing the leg for the hanger bolt

- Test-assemble the leg and rail and plate assembly again and mark the hole on the stock for the hanger bolt provided with the hardware kit.
- Fit your drill press with a brad-point bit and bore a pilot hole for the bolt utilizing a shop made V-block jig.
- Repeat for the other legs.

4 - Fastening the leg to the rails

- Insert the screw thread end of the hanger bolt into the pilot hole in the leg.
- Unlike other fasteners, a hanger bolt has two types of threads: screw threads at one end and machine threads at the other; it also has no head.
- Screw two nuts onto the machine thread end and tighten them against each other with two wrenches, forming a temporary head on the bolt.
- Tighten the bolt with one of the wrenches to drive the screw threads into the leg, and then unscrew the nuts from the bolt.
- Slip the rail and plate assembly over the bolt and screw a nut on it.
- Keeping the top of the rails flush with the top of the leg, tighten the nut.

Utilizing a shop made leg hardware

- You can attach a leg to rails utilizing a wooden corner block, a hanger bolt, and four screws.
- Begin by making the corner block.
- Cut a piece of wood thin enough to drive a hanger bolt through it into the leg.
- Then make a 45 degree miter cut at each end.
- Then, saw grooves for splines, which will help join the block to the rails.
- Install a dado head on your table saw with a width and cutting height equal to one-third the thickness of the rails.
- Screw aboard to the miter gauge as an extension, and then align the midpoint of one end of the block with the blade.
- Clamp the block to the extension.
- Butt a waste piece from the miter cuts against the work piece to serve as a stop block and clamp it to the extension.
- Feed the stock into the blades, then turn it over and cut a groove in the other end.
- Then, mark two holes on each side of the clearance hole and drill countersinking holes, and then install a smaller bit to drill clearance holes for the screw shanks.
- To join the leg and rails, first fasten the corner block to the rails.
- Spread some glue in the grooves in the block and the rails, and insert the splines into the grooves in the block.
- Then hold the block against the rails and screw it in place.
- Prepare the leg as you would for commercial hardware, cutting a notch out of the top for the corner block and boring a pilot hole for a hanger bolt.
- Fasten the leg to the rails with the bolt, slipping a washer amongst the nut and the corner block.
- Tighten the nut until the leg and rails fit snugly together.
- Test fit the block against the rails, and then mark and cut the grooves in the rails.
- Now cut the splines, making them 1/16 inch shorter than the combined depth of the two grooves.
- Plane the splines cautiously to ensure that they fit precisely in the

matching grooves.

- For maximum strength, ensure that the grain of the splines runs across their width, rather than along their length.
- Now bore countersinking and clearance holes for the hanger bolt and screws that will secure the brace to the leg and rails. Install a brad point bit in your drill press and mark the center of the long edge of the block for a hanger bolt.
- Secure the work piece in a hand screw and clamp it to the drill press table, with the center aligned with the bit.
- Then bore the hole.

Bonus Chapter How to make tops

Most tops for tables and desks are made by edge-gluing boards together. Few boards are obtainable that are wide enough and most of those would be unsuitable, because of the tendency of wide planks to twist and cup.

Nevertheless, by selecting boards cautiously and matching them for color and grain direction, you can create the illusion of a single piece of wood. Assess the color and grain of lumber by planing the exterior lightly to reveal what lies underneath a plank's rough exterior.

A sturdy, flat top starts with appropriate preparation of stock. Ensure you utilize kiln-dried wood or wood that has been stored long enough in the shop to have a moisture content amongst 8 and 12 percent. Allow moisture content means that the wood will be rather stable.

Also steer clear of bowed or twisted boards. Since numerous tops have a completed thickness of $\frac{3}{4}$ inch, $\frac{4}{4}$ rough-sawn stock is an ideal choice as it allows you to plane and sand off up to $\frac{1}{4}$ inch of wood.

Wide tops are rarely glued up all at once because it is much easier to thickness plane several smaller panels than one large one. The glue up sequence you follow for your ventures will depend on the completed width of your top, and the size of your planer.

For instance, if you own a 12 inch planer and want a 30 inch wide table top, it is best to glue up three 8 to 12 inch wide panels and plane them individually, before gluing them into a single top.

To help keep the boards aligned while glue-up, some woodworkers utilize dowels or biscuits spaced every 6 to 8 inches, While this is not essential.

Unlike standard tables, the grain for tops for extension tables should be perpendicular to the table's length. Ideally, utilize quarter sawn stock for these tops, as well as for the leaves.

After the glue has dried and the panel has been planed, the edges of the top can be fashioned. With drop leaf and gate leg tables, this shaping is done before the joinery. One exclusion is the round drop leaf table; its leaves should be installed before the circle is cut to ensure that the table will be perfectly round.

Procedure

1 - Jointing the boards

- Prepare each board by first jointing a face and an edge, and then plane the other face.
- Then, roughly crosscut the boards, leaving them about 1 inch longer than the top's final length.
- Rip the stock so that the combined width of all the boards is roughly 1 inch wider than the completed top, then joint all the cut edges.
- Then, arrange the boards for appearance, taking into consideration any leaves if you are making an extension, drop leaf, or gate leg table.
- Leaves are typically glued up separately from the table top.
- To minimize warping, arrange the planks so the end grain of adjacent boards runs in opposite directions.
- When you are satisfied with the arrangement, utilize a pencil or chalk to mark a reference triangle on top of the boards.
- This will help you correctly realign them for glue-up.

2 - Applying the glue

- To hold your bar clamps upright while glue-up, cut notched wood blocks and set the clamps in the blocks.
- Space the clamps at least every 24 to 36 inches.
- To avoid marring the edges of the panel when you tighten the clamps, cut two wood pads as long and as thick as the boards being glued.
- Apply a narrow bead of glue to one edge of each joint and utilize a small, stiff-bristled brush to spread the adhesive equally on the board edges.
- Move rapidly to step 3 before the glue begins to set.

3 - Tightening the clamps

- Lay the boards face-down on the bar clamps and align their ends,

making sure the sides of the reference triangle are lined up.

- Tighten the clamps under the boards just enough to butt them together.
- To balance the clamping pressure and keep the panel flat, place bar clamps across the top of the panel amongst the ones underneath.
- Finish tightening all the clamps in turn until there are no gaps amongst the boards and a thin, even bead of glue squeezes out of the joints.
- Eliminate excess glue with a scraper or a damp cloth.

How to size a top

- Once the top has been glued up, rip it to width and trim it to final length.
- If the top is too large to cut on your table saw, utilize a router fitted with a straight bit.
- First, secure the top on a broad work exterior and cut it roughly utilizing a circular saw, leaving about 1/8 inch to trim on all sides.
- Clamp an edge guide to the tabletop near one side so that the router will eliminate about one-half the waste with the first pass; rearrange the depth of cut to trim the rest of the waste.
- Repeat for the other edges.

How to make a round top

- Scribe a circle on the glued-up top and make the cut with a router.
- For small-diameter tops, you can utilize a commercial compass jig; to cut larger tops, utilize the shop-built compass jig in the inset.
- Make the device from $\frac{1}{4}$ inch hardboard, sizing it to suit your router.
- Cut the router end of the jig to the size and shape of your tool's base plate, and make the arm at least 2 inches wide and longer than the radius of the circle you will be cutting.
- Bore a clearance hole for the bit in the center of the router end, and fix the tool to the jig.
- Draw a line down the center of the jig arm and mark the radius of the table top on it, measuring from the edge of the bit.
- Drill a hole at this center mark and screw the jig to the center of the work piece.
- Secure the stock to a work exterior with cleats and a scrap board underneath.
- Plunge the bit into the stock and rout the circle in a clockwise direction.
- Make the cut in two or more passes, increasing the depth of cut amongst each pass.

How to attach the top

- Attaching a top to a table or desk is a straightforward task so long as you review wood movement.
- Screwing a top in place without providing for the swelling and shrinking that occurs with humidity changes will result in split or cracked wood.
- Because wood expands along the grain much less than it does across it, most tops are made with the planks running lengthwise.
- One exclusion to this rule is extension tables, where the grain must be aligned across the width of the table so that the two halves do not expand in width at different rates, causing the slides to bind.
- For each of these techniques, the rails of the leg-and-rail assembly need to be prepared for the top before the legs and rails can be glued up.

How to screw the rail to the top

1 - Drilling the holes

- To attach a table top or desktop to a leg and rail assembly bore a series of countersunk holes in each rail for the screws, before the legs are joined to the rail.
- Drill the holes on a drill press in two steps.
- First, bore holes at 6 inch intervals about halfway through the thickness of the rail.
- Clamp an edge guide to the drill press table to keep the holes in line.
- To accommodate the movement of the top, the holes should be larger than the diameter of the screw heads you will be utilizing.
- In the second step, bore clearance holes rather larger than the screw shank all the way through the rails.

2 - Attaching the rails to the top

- Set the top face down on a work exterior, and center the leg-and-rail assembly on it.
- Screw one side rail to the top first, utilizing washers to allow the wood to move.
- Square the top, and then screw the opposite side rail in place.
- Lastly, screw the two end rails to the top.

How to drill the holes

- You can utilize an electric drill and a commercial jig to drill pocket holes for attaching the top to a leg-and-rail assembly.
- Follow the manufacturer's instructions to adjust the jig to the desired depth of cut and clamp it to a work exterior with a backup board against the stock.
- Plunge the bit into the wood, making the pocket cut.
- Then, fit a drill with the bit supplied with the jig and bore a clearance hole connecting the pocket hole to the top of the rail, utilizing the kit's guide bushing to direct the operation.
- Space pocket holes every 6 inches.
- Screw the top in place.

How to make a wood buttons

1 - Making a wood buttons

- To attach a top utilizing wood buttons, you will need to place a wood button every 6 inches along the rails.
- Begin by cutting a groove on the inside face of each rail about $\frac{3}{4}$ inch from the top.
- You can cut several 1 by 1 $\frac{3}{4}$ inch buttons from a single board; make the thickness of the stock equal to the gap amongst the bottom of the groove and the top of the rails, less $\frac{1}{16}$ inch.
- Cut a rabbet to fit the groove at each end of the board, then rip the board into 1 inch strips on a band saw and cut off the buttons about 1 $\frac{3}{4}$ inches from the ends.
- To make holes in the buttons for installation, utilize an L fashioned corner jig produced from a scrap of $\frac{3}{4}$ inch plywood and two pieces of wood.
- Clamp the jig to your drill press table and steady the buttons with a hold-down produced from scrap wood.
- Bore through the centers on the unrabbeted portions of the buttons.

2 – How to install the buttons

- Center the glued-up leg-and-rail assembly on the table top and screw it to the top utilizing the wood buttons you cut in step 1.
- Fit the rabbeted ends of the buttons into the groove in one of the side rails, spacing them every 6 inches.
- Screw the buttons in place, leaving a $\frac{1}{8}$ inch gap amongst the lipped ends of the buttons and the bottom of the groove to allow for wood movement.
- Square the top and install the buttons at the opposite side.
- Lastly, install the buttons along the end rails.

How to install fasteners

- Desktop fasteners are a popular choice for attaching tops.
- Installed in shallow notches so they lie flush with the top of the

rail, they are then screwed into the top.

- The fasteners can pivot rather back and forth as the top swells and shrinks.
- To install the fasteners, rout or chisel out recesses for them in the top of each rail, spacing the notches every 6 inches.
- Screw the hardware to the rails, and then center the leg-and-rail assembly on the top and screw it in place through the fastener.

How to square the top

- Before screwing atop to a leg-and-rail assembly, ensure that the exterior is centered and square.
- A bar clamp and wood pads will do this.
- Place the top good side down on a work exterior, set the leg and rail assembly on top, and attach one side rail to the top.
- Butt one jaw of a bar clamp against the edge of the top at one end, and the other jaw against a leg at the opposite end.
- Use wood pads to prevent marring the stock.
- Measure the distance amongst the edge of the top and the end rails at several points at both ends.
- All your measurements should be equal.
- If not, square the assembly by tightening the clamp.
- Confirm the measurements, then screw the opposite side rail to the top.
- Eliminate the bar clamp and screw the end rails in place.

Adjustable tops

Not everyone has the space for a large dining table, while the extra exterior area is often required. One solution is a table with an expandable top. There are several choices open to you.

Drop-leaf tables typically have long leaves parallel with the grain that hang out of the way when not in use. Small leaves may be supported by a pull-out bar.

Large leaves that more than double the exterior area require swing legs or gate legs to be added. Swing legs are part of a four-legged leg-and-rail assembly; gate legs are an supplementary set of legs used precisely for support.

If you want to increase a table's length, extension tables feature tops that split open on sliders to accept supplementary spacer leaves. Extension tables can be built so that the entire table opens, or just the top.

Adjustable tops are made in much the same way as solid wood tops, with a few vital exclusions. Drop leaves are best glued up from quarter sawn wood, where the growth rings are at right angles to the face.

This will decrease the tendency of the wood to cup. Since it shrinks and swells less than plain-sawn stock, quarter sawn wood is also ideal for the tops of extension tables, where the grain runs across the width of the table.

How to make a rule joint for a drop leaf table

1 - Routing the cove in the leaves

- The easiest way to make a rule joint is by utilizing a matched set of piloted cove and round-over router bits.
- First, install the round over bit in your router and shape a bead around the table top and the three outside edges of the leaves.
- Make the cut in several passes, leaving a 1/8 inch lip around the edge.
- Then install the piloted cove bit and mount the router in a table.
- Align the fence with the bit pilot so the width of cut equals one-half the cutter diameter.
- Set the depth of cut shallow at first; make several passes to reach your final depth gradually.
- Feed the table leaf into the bit, pressing the edge of the work piece firmly against the fence.
- After each pass, test fit the pieces until the table top and the leaf mesh with a very slight gap amongst the two.

2 - Installing the rule joint hinge

- Position the shorter hinge leaf against the underside of the table top and the longer hinge leaf against the table leaf; the hinge pin should be aligned with the start of the round-over cut on the table top.
- Offset the hinge pin 1/32 inch toward the edge of the table top for clearance.
- Outline the hinge on both the table top and the leaf and rout out the waste.
- Chisel out the mortises to accept the hinge pins, and then screw the hinges in place.

Drop leaf supports

- If commercial drop-leaf supports are too bulky for your table, you can simply make supports that will complement your design.
- Before attaching the leg and rail assembly to the table top, cut two notches in the top edge of each side rail adjoining a drop leaf.
- The notches should be about 6 inches from the ends of the rail and sized to fit the supports you will make.
- For each leaf, cut two supports from the same stock you used to build your table.
- The supports should be sufficient to hold the drop leaf; cut 2 inches wide and 14 inches long from $\frac{3}{4}$ inch thick stock.
- To prepare the supports, you need to rout two grooves down the middle of each one to accommodate screws and washers.
- Cut one groove halfway through the support rather wider than the washers you will use; center the second groove in the first one, making it rather wider than the screw shanks and cutting right through the support.
- Both grooves should stop 2 inches from each end of the support.
- Attach a knob to one end of the support to make it easy to slide in the rail notch.
- Set the fully assembled table upside down on a work exterior, slide the support into the notch, and position it so that it supports the leaf.
- Install a screw and washer into the top at the inside end of the groove, driving the screw until it meets the washer.
- This screw will be the support's outward stop.
- To mount the inward stop, retract the slide so the knob end is flush with the rail, and install a second screw and washer the same way as the first.

Conclusion

Woodworking can be tremendously satisfying and even life-changing hobby! Producing work with wood can lead to skills you never knew you could have and maybe even fatten your wallet, and who wouldn't like that!

Still, while most of these projects only require a minimum of hand tools, portable power tools and a minimum of woodworking experience, don't expect to have a lavish and perfect table the first time you make one.

Rather have fun and try out new techniques and using different tools as many times as possible. Take the first step and dive into woodworking! You won't regret learning this life-changing skill.

Lastly, if you found this book valuable in anyway, a review (good or bad) is always appreciated!

About the Author

Paul Berger was born in Carros, France nearby Nice in 1958. After finishing his studies at the University of Nice Sophia Antipolis, Paul moved to Canada where he got introduced to Woodworking. Paul has begun working in Calgary to a local Woodworking Design and Home Improvement shop where he spent the next 32 years until his retirement.