
PlyDesign

I would like to dedicate this book to all of the creative people whose work fills its pages, and to my daughter, Leigh, who began her official design work at age two, building ambitious structures with dozens of baby board books. I have no doubt that the parents of every one of this book's contributors have a similar story to tell. – PS

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Edited by Nancy Ringer and Lisa Hiley
Art direction by Alethea Morrison
Book design by MacFadden and Thorpe

Pencil renderings by Michael Gellatly
Technical drawings by Peter Sherratt
Cover photography by:

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Indexed by Nancy D. Wood

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PlyDesign

**73 Distinctive DIY Projects
in Plywood (and Other
Sheet Goods)**

Philip Schmidt



Storey Publishing

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Shop Talk

Buying, hauling, and working with sheet goods: an unhandyman's guide to understanding plywood (and its woody cousins).

A Panel Discussion: All about Plywood

Plywood is the head of a growing family of wood-based panels generically referred to as sheet goods, or sheet stock. All of these fall under the category of *engineered wood*: building products that start out as trees and, after a good deal of industrial processing, end up as interchangeable products made to precise specifications. While solid wood has many undeniable merits, the beauty of the engineering is that it removes or counteracts some of wood's biggest drawbacks – namely, knots and other natural flaws, shrinkage and expansion, and warpage, plus the fact that you can't buy a nice solid-wood board wider than 11¼" without refinancing your house.

HOW PLYWOOD IS MADE

Plywood gets its unique blend of strength, stability, and economy from its layered construction. A plywood panel is made up of thin plies, or veneers, of wood glued together under pressure and heat. Each ply is laid perpendicular to the plies above and below. This process, called cross-graining, is key to plywood's strength and dimensional stability. Moisture causes wood to expand and contract mostly *across* its grain (a board gets wider and narrower rather than longer and shorter). Cross-graining effectively suppresses this movement. A plywood panel keeps its shape and doesn't constantly shrink and expand like solid wood.

Wood is by nature much stronger in line with its grain than across it. Cross-graining builds upon this strength, making plywood equally strong in all directions. This may be why ancient Egyptians used laminated wood to build caskets, some of which are still holding up today.

Cross-graining gives plywood edges a striped appearance, created by the alternating layers of end grain and face grain. In traditional styles of woodworking, the stratified edges are typically concealed by a band of solid-wood trim or other material, creating the illusion that the plywood is a solid plank. In the modernist style, not only are the plywood edges left exposed, they're often a major design element.

The plies for making plywood are cut by a big, lathelike machine that rotates a log by its ends while a long knife strips off the wood in a continuous thin layer, sort of like an old-fashioned apple peeler. For certain grades and outer veneers, some plies are cut across the log (called slicing). This yields a grain pattern more like that of solid lumber than does rotary cutting, which

follows the wood's growth rings and produces wide, wavy patterns of grain.

The top and bottom layers of a plywood panel are called the face and back veneers, respectively. These are the plies that count, aesthetically, and they're usually the thinnest layers in the sheet (but thicker is always better). So that the grain of the face veneer runs in the same direction as the grain of the back veneer, all plywood is made with an odd number of plies, ranging from 3 up to 17, including the face and back. Generally speaking, the more plies, the better the plywood.

Workers make plywood at a wood processing plant in northeast China.



PLYWOOD GRADING

The language of plywood can be much more complex than you might expect when talking about big slabs of wood. And as with most building materials, the terminology is anything but universal. So even if you memorize everything explained here, don't be surprised if things aren't the same at your local lumberyard, and try not to feel belittled, as when talking to a computer support technician. The bottom line is that you'll know what you want when you see it at the yard (and don't be afraid to be choosy with the stock).

For furniture pieces or any decorative work where you want the edges to show, it's best to stick with Baltic birch (see page 12) or a general group of cabinet-grade, or furniture-grade, material generically called *hardwood plywood*. This plywood is made with all-hardwood plies and is much less likely to have voids within the plies than standard plywood, which often contains layers of softwood (Douglas fir, pine, et cetera). Also, the edges of hardwood plywood machine and sand more uniformly than those of standard plywood. Voids are a problem because they leave you with unsightly cavities in cut edges, and there's no way of knowing where they are before you make the cut.

A plywood panel gets two grades, one for the face veneer and one for the back. The most common standard grades for face veneers, from best to worst, are N, A, B, C, and D. With hardwood plywood, N and A grades should be "clear" or stain-grade, meaning they look good enough not to be painted. B-grade veneers are smooth and have only minor flaws but may contain patches; they are generally used for the back or less-exposed side of a piece. C-grade is used for fully concealed surfaces, like the back of a bookcase. D might as well be code for Downright Ugly; it's found only on construction-grade material.

For back veneers, some suppliers assign one of these letter grades, while others use a number, such as 1, 2, or 3. Typically, the number grades of 1, 2, and 3 are loosely equivalent to an A-minus, B, and C, respectively.

Veneer Matching

In addition to the general grading, the face veneers on cabinet-grade plywood can be categorized according to how they're made. A face made with a single sheet of wood, with no seam, is called single-sheet, or whole-sheet, veneer. When the face is made of two or more sheets butted together lengthwise, it's "matched" veneer, categorized according to how the grain pat-

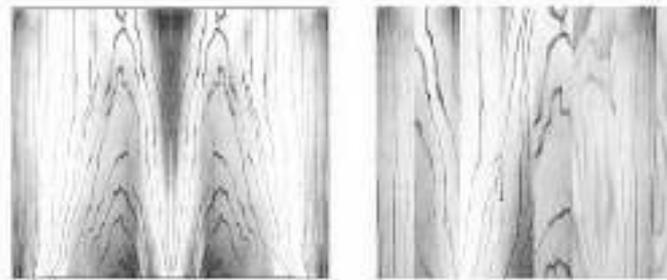
terns of the different pieces are arranged. *Book matched* veneers consist of two mirror-image patterns opened like a book and laid flat. *Plank matching* arranges mating pieces so all the grain runs in the same direction, but the grain patterns are random. This results in a look that's most similar to sawn boards that are edge-glued together. It's not quite as dramatic and interesting as book-matched veneer, but it looks more realistic to a discerning eye. Both book-matched and plank-matched veneers are arranged for consistent coloring. *Unmatched* veneers (typically rotary-cut) are arranged with no intentional order to the grain or color.

PLYWOOD SIZING

A standard "full sheet" of plywood is 4 feet wide and 8 feet long. Some suppliers sell sheets in smaller pieces, such as 2 x 4 feet and 4 x 4 feet, while online you can find such oddities as 12" squares of Baltic birch for about \$2. And sometimes that's all you need. Length and width measurements are generally true to the named, or nominal, dimensions.

Sizing is not quite as simple when it comes to panel thickness. Standard thicknesses are as follows, in inches: $\frac{3}{16}$, $\frac{1}{4}$, $\frac{3}{8}$, $\frac{1}{2}$, $\frac{5}{8}$, and $\frac{3}{4}$. Some suppliers also offer 1"-thick material. Seems simple enough, but don't be surprised if you run into nominal (and actual) dimensions like $\frac{7}{32}$ ", $\frac{15}{32}$ ", and $\frac{23}{32}$ ". The lumberyard staff will probably still call these $\frac{1}{4}$ ", $\frac{1}{2}$ ", and $\frac{3}{4}$ ", respectively.

When working on projects, be sure to measure the actual thickness of your material, and always run test cuts for things like dadoes, rabbets, and slots. Assuming your stock is $\frac{3}{4}$ " when it really measures $\frac{23}{32}$ " could get you into trouble.



Book matching (left) results in a dramatic, if not particularly realistic, display of wood grain. Plank matching (right) is an assembly of typically narrower strips, with the grain aligned more or less vertically.

Other Sheet Goods You'll Find in This Book

While most of the projects here use hardwood plywood as the primary material, a handful of designs call for different engineered wood products. And you can make substitutions with a fair number of designs – for example, using MDF instead of plywood.

MDF

Medium-density fiberboard comes in 4 x 8-foot panels made of tiny wood fibers glued and pressed into a perfectly uniform, color-through material. The color happens to be a dull puttyish hue that can look pretty good with a clear finish, but most applications call for paint. MDF has no layers (and no voids) and cuts and routs like butta'. It's a good substitute for plywood on painted projects because it's cheaper, takes paint better, and is sanded smooth at the factory. MDF is also dead flat, with no surface deviations whatsoever.

The main drawbacks of MDF are important to note: When unfinished, this material is highly susceptible to water damage; imagine a roll of paper towels set down on a wet countertop. Its compressive strength (flat pressure) is high, but its tensile (bending) strength is much lower than plywood's. You also must be careful when screwing or nailing MDF: it splits or chips if you're too close to the edge, and screws can strip out fairly easily, especially on the edges. Always drill pilot holes for fasteners in MDF, and seal the edges before painting (see *Finishing Plywood and MDF*, page 20). Finally, be prepared for a blizzard of dust when cutting or milling MDF, and work outside whenever possible. The dust is superfine, and it gets *everywhere*.

MDF-CORE & COMBINATION-CORE PLYWOOD

Regular plywood, with all natural-wood plies, is technically called "veneer-core" plywood. You need to know this only to distinguish it from a group of plywoods made with one or more layers of MDF. *MDF-core plywood* is a nearly full thickness of MDF with face and back veneers of real wood. It's very flat, and it's void-free, but it has the same drawbacks as regular MDF.

Combination-core plywood has a center of three or more wood plies sandwiched by layers of MDF and finished with pretty wood veneers. The result is a panel that's stronger than



MDF



MDF-core plywood

MDF with ultraflat surfaces that you can't always get with conventional plywood. Both of these hybrids are a good option for large, flat panels that will have their edges covered (with solid wood, veneer edge tape, mating panels, et cetera).

BAMBOO PLYWOOD

This is the new kid on the block, and he's very proud of how green and cool he is. He's made with cross-grained layers of bamboo, which acts like wood but is really a woody grass. The layers consist not of thin plies but of narrow, edge-glued strips of solid bamboo, making for very distinctive edges and very beautiful faces. Bamboo is considered an environmentally friendly natural resource because of its rapid renewal rate –



Bamboo plywood



OSB



Hardboard

some species can be harvested and replenished every three to five years.

Bamboo plywood is a strong performer and comes in a limited range of colors, including natural blonde, carbonized (a dark brown created by boiling the raw material), and an eye-catching “zebra” whose pattern comes from a blending of light and dark layers. Panel thicknesses range from $\frac{1}{40}$ " to $\frac{1}{4}$ " single-ply veneers to $\frac{1}{2}$ ", $\frac{3}{4}$ ", and 1" laminated structural panels. As of this writing, the price of 4 x 8-foot bamboo panels can range from 30 to 100 percent more than that of hardwood plywood, but prices are trending downward as the material reaches a broader market.

OSB

Oriented-strand board is similar to plywood, but it looks like someone put the plies in a blender before gluing up the panel. It's made up of a few layers that are cross-grained, like plywood, and has two outer layers that share the same “grain” direction. OSB is cheap and reasonably strong. In specific applications, it can be a good plywood substitute, whether for economy or the interesting look of its surfaces; for example, it looks pretty cool with a semitransparent paint job.

HARDBOARD

Also known as high-density fiberboard or by the popular brand name Masonite, hardboard is commonly available in 4 x 8-foot sheets of $\frac{1}{8}$ " or $\frac{3}{16}$ " thickness. It's dark brown and has one smooth side and one rough side, which has a slight waffle-grid texture. Hardboard is, literally, pegboard without the holes. You won't use it for any building projects (unless you really want to), but it's a good material for making templates for tracing and routing your workpieces. Hardboard is thin, void-free, and much easier to cut and shape than $\frac{3}{4}$ " plywood, for example. It's also very cheap, so you won't mind messing up a template or two.

Where to Buy Sheet Goods

Now to apply all that we've learned to the real world: If you browse the aisles at a local “big box” home center, you'll likely find lots of construction-grade plywood (for things like roof sheathing and subflooring), as well as $\frac{3}{4}$ " ($2\frac{3}{32}$ ") plywood with red oak and birch face veneers. This is pretty standard seven-ply stuff and will

Baltic Birch – From Russia, with Love

Beluga caviar notwithstanding, Baltic birch plywood may be Russia's finest export. Made with all-birch plies from the Baltic regions of Russia and Finland, Baltic birch (or BB) has long been a standard choice for cabinetmakers, furniture designers, and woodworkers. In short, it's a good, cabinet-grade material, with thin, even plies and quality face veneers (typically single-sheet). It's also a good deal, starting at about \$75 for a full 5 x 5-foot sheet of $\frac{3}{4}$ " stock.

And you read that right: most BB plywood comes in a 5 x 5-foot sheet. It's an odd size, for sure, but it's really handy when you'd rather have a little more width instead of length. Some American suppliers carry 4 x 8-foot sheets, and many offer smaller sizes in a range of thicknesses.

As mentioned, some BB comes from Finland and is considered by some purists to be superior to "Russian birch," but you can't go wrong with either. For furniture projects, look for Baltic birch in B/BB-grade (not to be confused with the Baltic birch abbreviation). This has a clear, single-sheet face veneer and a nice, if sometimes patched, single-sheet back veneer.



Baltic birch plywood has consistently thin, virtually void-free plies that make for beautiful milled edges. The light-blonde face veneers are great for clear-coating, oiling, or staining.

probably have some voids inside, so it's not the best choice if really nice exposed edges are important.

Be very wary of 2 x 4-foot precut panels that are often sold in an aisle endcap. Sometimes these panels can have decent-looking face veneers, but always check the edges: if the plies are inconsistent and overlapping instead of flat, continuous layers, you don't want the panels, unless you're using them to hurricane-proof windows.

Other sheet goods, including MDF, OSB, and hardboard, are likely to be of the same quality at big boxes as anywhere else.

A better option for finding good plywood is a well-stocked lumberyard or hardwoods supplier. Lumber prices can vary widely even in the same town, so it's best to call around first. Always ask how many sheets they have in stock – you don't want to make the trip only to find that their "selection" is one sheet from the bottom of the bundle.

Lumberyards often carry a few sizes of hardwood plywood in birch, oak, maple, apple, and other common veneer species, as well as Baltic birch (see box at left). Hardwoods suppliers will carry all that plus cherry, walnut, alder, hickory, and things you've never heard of, like wormy maple, kewazinga, and afromosia. Prepare for severe sticker shock with some of these species.

Considering how much mileage you can get out of a full sheet of plywood, it's a real bargain compared to clear solid lumber. Try to keep this in mind when you're out shopping. It's almost always worth it to spend a little more for good plywood, both for the all-important void avoidance and for quality face veneers.

Hauling & Storing Sheet Stock

For beginners, trying to wrestle a full sheet of plywood to the top of a car can quickly turn into a Buster Keaton routine, spelling certain embarrassment at the lumberyard. The following tips can help you get your goods home safely with your pride intact.

First, here's the one and only proper way to lift a panel: Stand it upright on one of its long edges. Position yourself at the rear end of the panel, with one hand on the top edge and the other ready to grab the bottom edge. Lift the panel enough to grab the bottom rear corner with the lower hand, then raise the rear end of the panel while pivoting the front bottom corner on the ground. Move both hands (along with the rest of your body) to

the center of the panel, then rock the panel back to raise the front end. Carry the panel with your hands in the same positions, tilting it against your shoulder at a comfortable angle.

If you're practical and nerdy enough to own a minivan (like this book's author), chances are you can lay down flat a full 4 x 8-foot sheet of plywood in the back, so that it sticks out only a couple of feet. The trick is to stack up a couple of shipping pallets (or a pallet and some 2 x 4s on edge) so the plywood rests above the seat brackets and the curve of the hatch door opening. The same thing works in many SUVs. Be sure to run a tie-down strap over the rear end of the panel to keep it from sliding out when your turbo boost kicks in (if only minivans came with turbo). For those of you with pickup trucks, you can stop snickering now and skip ahead a few paragraphs.

If you have a car, your only option for hauling a full or half sheet is to throw that sucker on the roof rack or the roof itself. Be sure to pad the roof or rack with a blanket, to protect the car and the panel. Center the panel on the roof. Open the doors, and strap the panel down through the doors, using ratcheting straps (webbing with come-alongs, or mini hand winches; you can buy a whole set of these for \$10 to \$15 at any home center) or strong rope. Don't use bungee cords, which are made to stretch, of course, and can't handle strong forces.

Next, run a strap or rope from the right front corner of the car over the panel crosswise, and tie it to the left rear corner of the car. Repeat with a crossing strap going from the left front to right rear. These are the most important tie-downs, because most of the wind uplift will come from the front. Drive home with care. And whatever you do, don't take the highway!

If hauling a full sheet just isn't feasible, you can have your panel cut into more manageable sizes right there at the lumberyard; see Making Straight Cuts, page 15. Or, if you're buying more than one sheet, you can probably have the panels delivered for free.

Once you get your material home, proper storage is key to protecting your investment. Above all else, remember to *keep it flat* and *keep it dry*. Stack panels flat, whenever possible, placing them back-face down on flat 2 x 4s or other scrap material to keep them off the floor. Stack multiple panels face-to-face, aligning their edges neatly. You can cover a stack to keep the material clean, but always allow for plenty of air circulation. If stacking is not an option, stand the panels up on their long edges, against a wall, and resting on top of some scrap 2 x 4s.

When you're moving panels around, be very careful to set them down gently, lest you ruin a perfect factory edge with a ding or gouge. As mentioned earlier, moisture will quickly ruin MDF, and it's not great for plywood either. That's the main reason to keep the panels off the floor or ground. All panels can start to sag if left upright for long periods, so find a place to lay them flat you won't get to them for a while.

Essential Techniques

Many of the pieces in this book employ special techniques for cutting curves and custom profiles and for setting up your own production line to create multiple identical parts. The techniques are generally simple and relatively foolproof, but often it's important to remember that you're working with engineered wood and not solid lumber, which you're probably more familiar with.

VENEER: THE BEAUTY AND THE BEAST OF PLYWOOD

Plywood's pretty face veneer makes it possible to have a 32-square-foot panel of luxuriously grained hardwood, but it's also the Achilles' heel of the material. At an average thickness of about $\frac{1}{32}$ ", veneer is easy to damage with any kind of tool, and mistakes often can't be sanded out as they can with solid stock. That said, once the panel edges are milled or trimmed and the material is finished, veneer faces and edges hold up quite well in everyday use.

The first thing to avoid is splintering. This is most often caused by saw teeth exiting the material as they cut. Circular saws and jigsaws (with standard blades) cut *up* through material, resulting

Plywood to Float Your Boat

While you won't find any boat projects in this book, if you're building a piece for outdoors, you might want to consider springing for marine plywood. This high-grade material is made with water-resistant, exterior-grade glue, so it's very resistant to delaminating due to moisture exposure. Marine plywood also has solid plies – that means no voids. However, it is not chemically treated for rot resistance (like some exterior-grade construction plywoods), so be sure to give it a good finish rated for outdoor exposure.

in splinters along the cut line on the top face of the stock. Table saws and most handsaws cut *down* and therefore splinter the bottom face. The best way to prevent splintering with portable saws is to score the cut line with a sharp utility knife, effectively cutting through most of the veneer before the saw blade sets its gnashing teeth to the delicate wood layer.

For straight cuts, start by marking your cut line with a pencil or marking tool, then score down the center of the line with a knife, using a straightedge as a guide. Make one light pass first, then repeat with increasingly forceful passes – two or three total should do it. Set up a straightedge so one side of the saw blade is precisely aligned with the scored line, and make the cut (see Making Straight Cuts, page 15). Scoring usually is necessary only when you're making crosscuts (perpendicular to the grain). Rip cuts (parallel to the grain) typically don't splinter much.

Curved cuts aren't so easy to score, but the tools used for these – namely, jigsaws and routers – don't cause splintering as much as circular saws do. If splintering is a problem with a jigsaw, switch to a finer blade with less "set" (the side angle of the teeth), or use a special down-cutting blade if you must cut from the top face. The latter is often recommended for cutting panels veneered with melamine or plastic laminate.

One of the best ways to dress an exposed plywood edge is to round it over with a router and roundover bit (see page 20), and any reasonably deep roundover will eliminate edge splinters. Easing an edge with sandpaper is less effective at removing splinter damage.

On the topic of sanding, you might be surprised how easily you can mar a veneer with the gritty stuff. Very thin face veneers (less than 1/32") may withstand little sanding before showing through to the layer below or disappearing altogether. And don't assume that premium plywood has thick face veneers. As a general rule, sand faces as little as possible, and be especially careful along edges, where the veneer recedes surprisingly fast with sanding. Use only fine-grit paper (at least 150 grit or so) on faces, as coarse paper leaves scratches that can be risky to sand out.

Are Sheet Goods Green?

Ecofriendliness is a highly debatable subject no matter what you're talking about, but it's safe to say that sheet goods are generally green because they optimize the use of wood, a renewable natural resource. Engineered products like MDF and particleboard are particularly stingy in their material use, since they're primarily made with recycled sawdust and wood pulp from lumber operations.

Plywood is resource-efficient because the best hardwood grades are reserved for the thin outer veneers, while lower-grade woods (which are often unsuitable as solid stock) can make up the interior plies. However, the manufacturing resources required to make engineered products can be greater than those for solid-lumber processing.

Where sheet goods aren't so green is in the adhesives used to bind the wood together. Most sheet goods are made with glue containing formaldehyde, a naturally occurring carcinogenic gas that's used in many building materials and furnishings. Traces of formaldehyde can be released into the air (offgassed) from exposed surfaces of plywood, MDF, and other sheet goods, such as particleboard. While the health risks to the typical homeowner are largely unknown, there have been reports of chemically sensitive people suffering from headaches and other symptoms believed to be caused by formaldehyde offgassing.

Interior (standard) plywood, MDF, and particleboard typically contain urea-formaldehyde binders, which offgas more than the phenol-formaldehyde binders used in many exterior-grade sheet goods. Some manufacturers offer sheet goods made with "no added urea-formaldehyde" (NAUF) or "no added formaldehyde" (NAF).

Back on the resource side of things: Some sheet goods are available from suppliers certified by the Forest Stewardship Council (FSC) and other organizations that award certification for sustainable forestry practices. For a list of companies that offer certified and/or no-added-formaldehyde products, visit the website of the Green Building Advisor (see Resources).



Crosscuts made with a circular saw are notorious for splintering face veneers.



A careful cut along a scored line greatly minimizes splintering. Always use a straightedge guide to keep your saw straight during this cut.

MAKING STRAIGHT CUTS

The factory-cut, or “factory,” edges of a sheet-good panel are your best friends in the workshop. These machine-cut edges are reliably straight and typically form perfect 90-degree corners (but always check your panel with a straightedge and a framing square just to be sure). This makes them ideal as references for laying out panel cuts and for using as critical edges and corners of a finished piece. For example, if you’re building a desk with long, straight sides, use the factory edge for the front side of the desktop, and make the rip cut on what will become the back edge.

But, alas, a new panel has only four factory edges and corners (and sometimes they get dinged along the way, which just isn’t fair). To make all of your other edges as close to factory perfection as possible, the best ordinary tools are a circular saw set up with a straightedge guide or, the woodworker’s choice, a table saw. If you own a table saw, I’ll assume you know how and when to use it, so I won’t explain it here. For those of you with a circular saw who are new to working with large panels, read on.

Setting up a circular saw for straight cuts is simple and takes just a little practice to become second nature. Here’s how it works: The rectangular metal (or plastic) base, or “foot,” of the saw has perfectly straight sides that are parallel to the blade. Therefore, if you clamp a smooth, low-friction straightedge over your workpiece and run the saw’s foot along the side of the straightedge, you’ll make a clean, straight cut with minimal burning (see Ring of Fire, page 16) and saw marks.



Using a straightedge with a circular saw

The only thinking part is measuring between the edge of the saw blade and the edge of the foot, then using that dimension for setting the distance between the straightedge and your cut line.

You can use a lot of different things for a straightedge; it just has to be straight, flat, smooth, and rigid enough to resist flexing during a cut. For cuts up to 4 feet long, a 4-foot level works quite well. Longer cuts pose more of a challenge. You can use a 6-foot level, if you have one, or create a homemade jig, using a 12"-wide piece of $\frac{3}{8}$ " or $\frac{1}{2}$ " plywood or MDF for the base and a straight piece of stock for the straightedge, or fence: Snap a chalk line onto the base, a few inches from one long edge. Screw the fence to the base, using the chalk line to keep it straight. Then run your circular saw down the base, with the saw foot against the fence – the saw trims the base at the precise offset between the blade and the straightedge. To set up a cut, simply align the edge of the base with the cut line, and clamp the jig down to the workpiece.

The key to success with a homemade jig is a perfectly straight fence, something that's hard to accomplish with most off-the-shelf lumber. A better option is a strip of $\frac{1}{2}$ " or thicker MDF or good hardwood plywood that includes a long factory edge.

You can also buy fabricated aluminum straightedge guides in a range of lengths. Some include integrated clamping devices, while others are just tracks that you secure with standard clamps. These are great as long as they're straight – and beware of two-piece models of questionable quality; any movement in the joint results in a flawed cut. People who make a lot of long

panel cuts often use a track saw, a circular saw with a special foot that rides along a track in a proprietary straightedge. These are ideal but certainly overkill for most hobbyists.

Another option for straight cuts is having them made at the lumberyard or home center where you buy the material. Lumberyards may charge for this service by the sheet or based on the time involved. Make sure you know exactly what sizes you need for each cut piece, and remember about the kerf – the material removed by the saw blade. The lumberyard may not guarantee accuracy greater than about $\frac{1}{8}$ ", and you can count on some splintering in crosscuts. Therefore, this is a good option for ripping a full sheet down the middle for easy transportation, especially if the dimensions aren't critical. While home centers often will make a few cuts for free, the quality of the cuts depends on the employee's experience and the fitness of the home center's panel saw; in other words, you're taking your chances here.

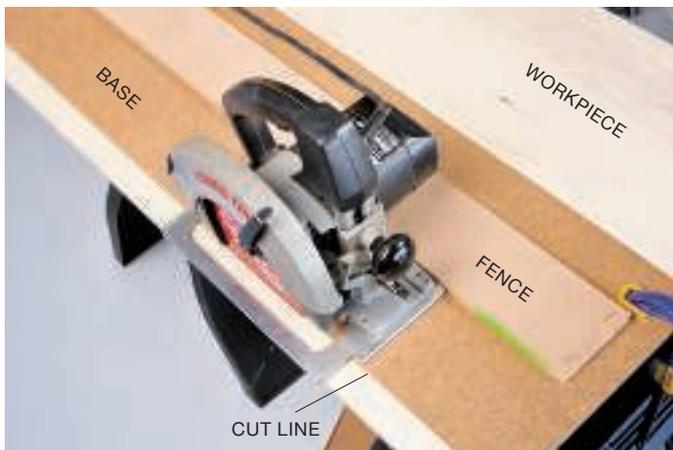
HOW TO MARK & CUT CURVES

Finally, a real-life application for grade-school geometry! Marking and cutting curves in sheet goods is pretty darned fun, and this book gives you hundreds of opportunities to hone these skills. Let's start with a very brief refresher course:

Diameter is the distance across the center of a circle.

Radius is half of the diameter.

The standard method for drawing curves and circles involves a compass. The "radius" of any curve is the distance between



Using a homemade straightedge jig

Ring of Fire

It takes just a few seconds of cutting for saw blades to get hot enough to burn wood. Circular saws and table saws are the worst offenders, as are routers and their incredibly fast-spinning bits. To prevent unsightly burn marks on cut edges, keep the saw (or workpiece) moving during the cut. The slightest hesitation or errant movement can result in a dark brown or black streak. You can sand these out, for the most part (and even the best woodworkers have to do this sometimes), but heavy sanding can ruin your straight edge. So it's best to avoid burns in the first place.

the pivot point on a compass and the drawn line. A small pencil-type compass that you can buy in any school-supply aisle will make radii up to 5" or 6". For larger radii, you'll need to create a homemade version. This is the simplest tool you'll ever love:

1. Find a thin, straight board or stick (a wooden yardstick is ideal).
2. Draw a centerline down the top face of the stick, parallel to its long dimension.
3. Use a utility knife to cut a small V-notch in one end of the stick, with the V's point meeting the centerline; this is for holding a pencil point in place.
4. Measuring down the stick from the point of the notch, mark the centerline at the desired radius.
5. Drill a hole at the mark, and tap in a small finish nail; the nail should be snug in the hole. This is the pivot point of the compass.

Now you're ready to mark curves like an old-school draftsman.

To lay out and draw a curve on a piece of stock, first plot the location of the pivot point. This is always equidistant from the desired ends of the curve. For example, if you're rounding off a square corner of stock with a 3" radius, the pivot point must be 3" from both adjacent sides of the material, as shown in the illustration on the top right.

To mark a large radius, start by drawing a centerline down the stock at the midpoint of the curve or workpiece. The centerline must be at least as long as the radius of the curve; if you run out of room on the workpiece, simply butt up a scrap panel to the workpiece, and continue the centerline onto the scrap, as shown in the bottom illustration.

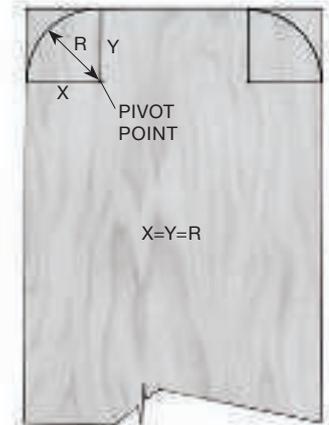
To mark the pivot point for your homemade compass, measure down the centerline and mark the line at the radius distance. Drill a pilot hole, and drive the finish nail through the compass and into the stock at this mark. Set a pencil into the V-notch, and pivot the stick and pencil on the nail to draw the curve.

To cut a curve of any size, you can use a jigsaw, a band saw (if available), or a router. The best method for cutting simple curves and circles is to make a rough cut with a jigsaw (or band saw), staying about $\frac{1}{8}$ " outside the cut line. Then come back with

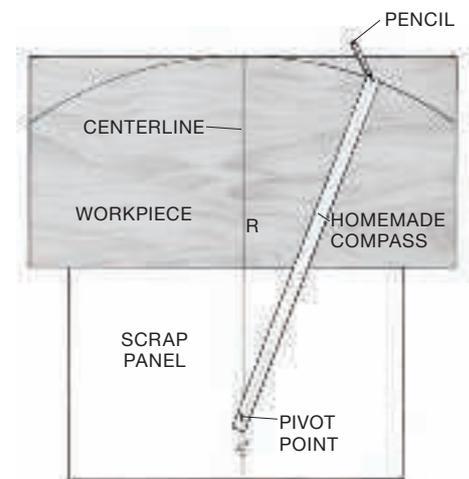
a router set up on a trammel to clean up the edge; see Two Easy Ways to Cut a Circle, below. For complex curves and custom profiles, you can carefully freehand the cut with a jigsaw or band saw, then sand the edges as needed to smooth and refine the curves.

TWO EASY WAYS TO CUT A CIRCLE

With the right setup, cutting a disk from sheet material is a piece of cake (or, rather, a piece of *pi*). Again, the best tool for this, by far, is a router.



For a small corner radius, plot the compass's pivot point by measuring from each adjacent side.



A compass made with a yardstick can draw radii up to about 36". Use an extra piece of stock material, if necessary, to draw a centerline for the compass's pivot point.

Router and Trammel

In woodworker's parlance, a trammel is a board that controls the motion of a tool. Here, a trammel works just like the homemade compass you'd use for marking curves (see the preceding section), except at the "business" end you have a router instead of a pencil.

You can make a trammel in about ten minutes: Cut a strip of $\frac{1}{4}$ "- to $\frac{3}{8}$ "-thick sheet stock about the width of your router base and 1 to 2 feet long. Draw a centerline down the top face of the board, parallel to the long dimension. Bore a large hole (for bit clearance) near one end of the board, centered on the line. Drill counterbored pilot holes through the bottom of the trammel centered on the clearance hole and mount the trammel to the router base with machine screws and washers as shown at top right (remove the router's plastic subbase first).

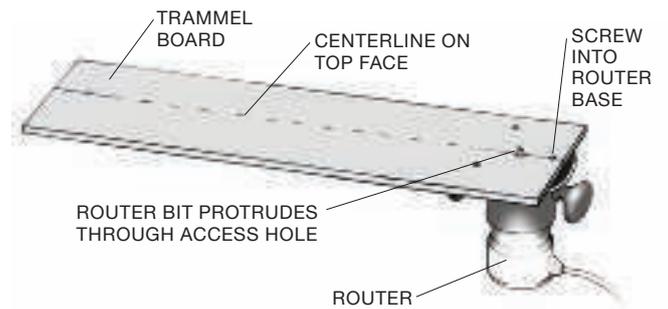
Set up the router with a two-flute straight bit or a spiral bit. To establish the radius of the circle on the trammel, measure from the innermost projection of the bit out along the centerline on the trammel, and mark the centerline at the radius distance. Drill a small hole at the mark for a finish nail.

Mark the circle on your sheet material with a homemade compass (see previous page), and rough-cut the disk with a jigsaw, cutting it slightly larger than you want it. This initial cut with the jigsaw is to reduce wear on your router bit, and it allows you to clean up the edge of the disk with one smooth pass of the router. Then position the trammel over the disk, and pin it down with a nail tapped into the same hole you used for the compass.

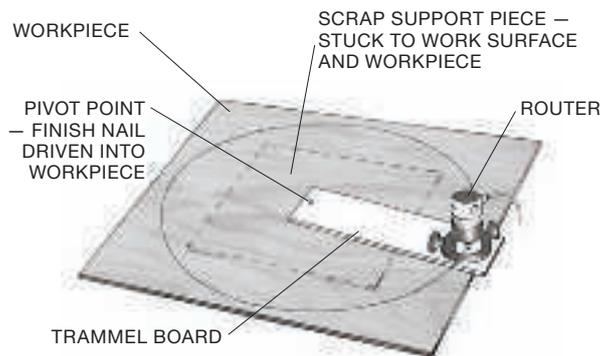
There's one catch to using a trammel here, and this applies only to fixed-base routers (plunge routers can simply plunge into the cut): with the workpiece rough-cut slightly large, there's no free access for the bit to initiate its cut. Here's one way to overcome this obstacle (note: any method you try is done *at your own risk*): Hold the trammel down with one hand and the router body with the other. Tilt the router up and back slightly, flexing the trammel, so the bit is free when you start the router. When the router is up to speed, carefully lower the router to engage the bit into the work. Complete the cut, moving the router counterclockwise around the circle.

Jigsaw and Trammel

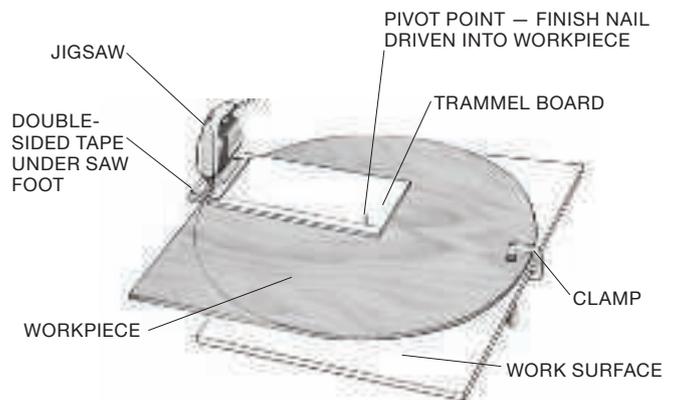
The same basic trammel setup used with a router works (almost) as well with a jigsaw. To make this jig, cut a strip of sheet stock a



Remove the router subbase, and mount the trammel to the router base using machine screws with the same thread size as the subbase screws.



To cut a circle in one pass, use a spacer and double-sided tape or other hold-down to secure the spacer and workpiece. Otherwise, clamp the workpiece over the edge of the bench and move the setup once to complete the cut in two operations.



A jigsaw with a trammel makes an accurate disk, if not as cleanly or efficiently as a router.

the end of the saw's foot. Use a square to draw a line across the board, a few inches from one end and a few inches from the board's edge; this line is perpendicular to the inside edge of the saw's foot. Then notch, centered to the pivot edge of the board, to provide clearance for the saw blade.

Draw a line parallel to the board's long edge, aligned with the blade's position, to secure the saw to the template with double-sided tape at the inside edge of the foot is on its reference line and the blade fits into the notched groove from the inside of the blade, and mark the pivot line at the radius distance and a hole and tap it in a nail here for the pivot point.

You can make the cut by starting with the blade snug against the edge of the workpiece, or hold a starter hole that just touches the edge of the circle.

TEMPLATE ROUTING

Template routing, also called *router routing*, is an important technique for many of the projects in this book. You'll use it to

make exact copies of a shape or profile on multiple workpieces. If you don't have a router, you should know that there are two alternative ways to do plate routing. If having the pieces cut on both left and right sides is as important as it is in a precision control project or labor project, or if you're using each piece individually (typically with a piece of band saw), then getting the axes together and cutting them together until they're as straight as the router's axis is preferable. If you do not have someone with access to a precision woodshop.

Template routing is simple and it's a great way for woodworkers and hobbyists to get the results that you can't get with a table saw or a lathe. It's a great way to get a lot of work done at once. It's best to use a router with a good way to hold it, and a hard wood or table for the base. Use these cutters and use them carefully and have no doubt in their minds. This is a very simple technique that you can use to make your own templates. However, it makes sense to make the template from an project that you ultimately use it on finished piece.

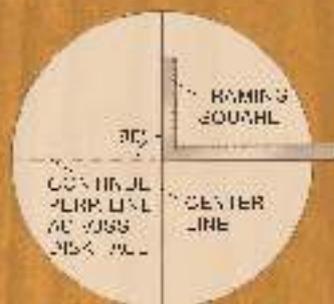
Make an accurate cut and sand to finish. Let the router cut the workpiece and use a router with a sharp cutting bit to make the cut. This is best because the router's edge is a straight line while the router's table is not. Use the template, creating an exact duplicate of the shape, by setting up the router to cut the workpiece. Even the router's imperfections in the cut will transfer to each workpiece, which may not be the same as the router's. Just make sure that they're lined up.

Edge finishing bits have an opening cut below the cutting edge. Top bearing versions are sometimes called "pattern" bits, while bottom bearing versions may be called "template" trimmers. With top bearing bits, the template goes on top of the workpiece, with bottom bearing bits, the template goes on the bottom.

As with cutting circles, it's a good idea to rough out the shape of the workpiece with a hand saw before routing with the template. Use the template to trace the shape onto the work, then cut to fit inside the lines with the saw. Don't let the template touch the work at the top or bottom, depending on the type of bit you have, using double-sided tape or small dabs of hot glue. Aren't you using the template and work to your benefit? It's a good idea to use a piece of tape or glue to prevent any shifting that could distort the finished product. Run the router side on one side, then move around the template in a counterclockwise direction.

Marking Quadrants on a Circle

To draw reference lines on a disk that you've just cut, first draw a line through the disk's centerpoint, aligning a straightedge with the hole left from the pivot nail. Next, place a framing square (or other flat-sided square) on the centerline, with the corner of the square on the center hole, mark along the perpendicular leg of the square. Use the square or straightedge to continue the second line across the face of the disk.





Surfaces I

Tables and desks, for dining, for work, for setting up on poker night
and knocking down when the guests have gone.



Florence Table

Designed by Cezary Gajewski

Perhaps more than any other piece in this book, the Florence Table celebrates the very best characteristics of plywood: strength, flexibility, uniformity, and beauty. Take a moment to study the table's leg structure and you'll see exactly what I mean. And you might be surprised to learn that this is also a knockdown design. The whole thing disassembles in minutes and packs flat into a 3-foot-diameter package. The shape and scale of the table make it ideal for small spaces, where it can seat up to four people – although you might have to look hard to find chairs that do the table justice.

MATERIALS

- One 36" x 36" sheet paper
- Two 35" x 35" sheets ½" MDF
- One 5 x 5-foot sheet ½" Baltic birch plywood
- Eight sets 1¼"-long Chicago bolts
- Finish materials (as desired)
- Four silicone bumpers (clear, low-profile, self-adhesive)
- One 36"-diam. tempered glass top, approx. 9 mm thick

TOOLS

- Quality HB pencil
- Framing square or T square
- Straightedge
- Scissors or utility knife
- Double-sided tape (non-foam-backed, clear)
- Jigsaw or band saw with fine-tooth wood blade
- Sandpaper (up to 220 grit)
- Router with ¼" and ½" flush-trimming bits
- Combination square
- Chisel
- Drill with straight bit(s) (see step 7)
- Screwdriver
- 4-foot level

Note: This project calls for a 36"-diameter round piece of glass with finished edges. The glass must be tempered for safety, so you have to order it from a glass fabricator (any glass shop can handle it). Tempered glass can't be cut – it's tempered after sizing – so this isn't a DIY option. Discuss your project with the glass dealer to be sure to get the right product for the application.

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