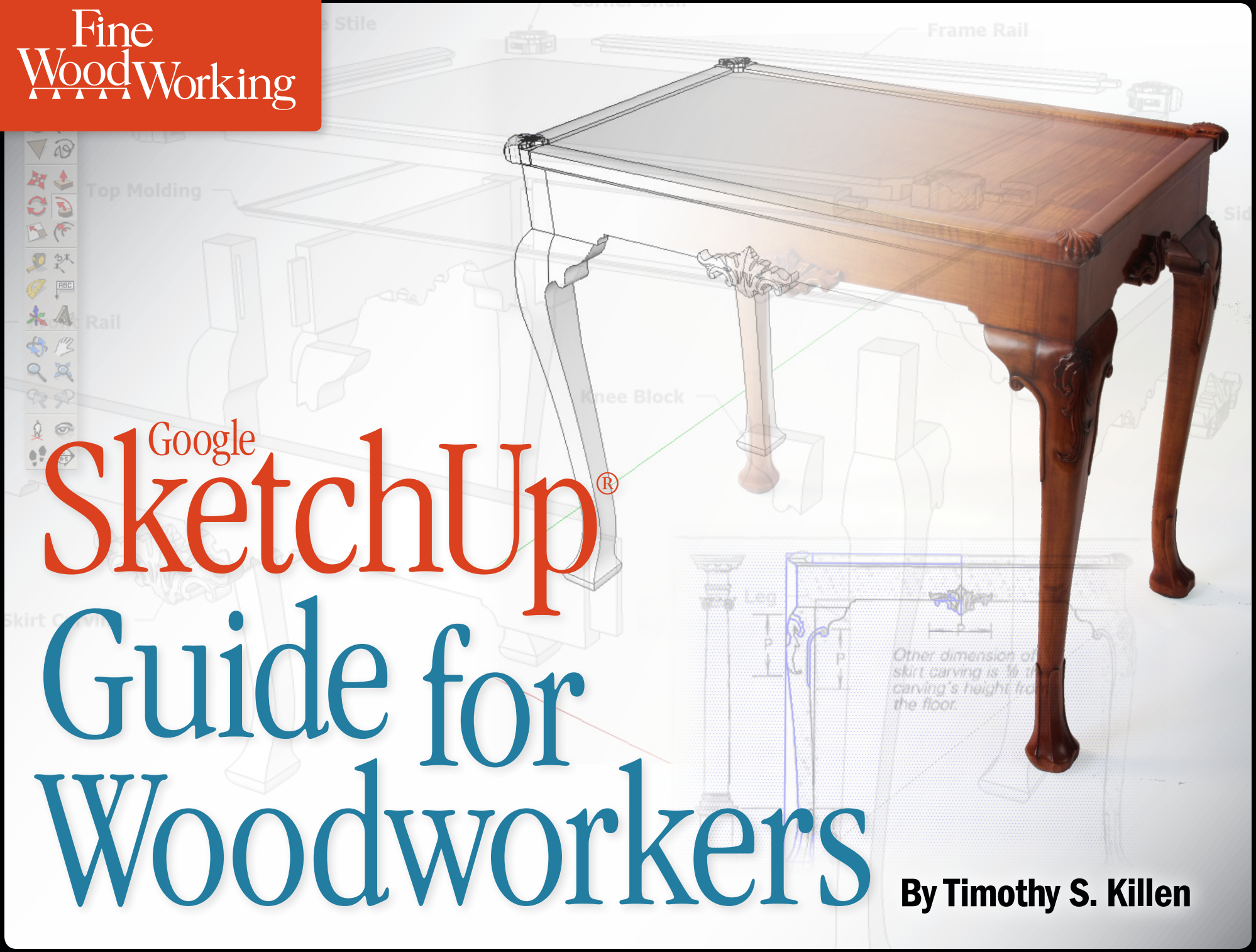
Fine WoodWorking



Google SketchUp® Guide for Woodworkers

By Timothy S. Killen

The Taunton Press
Inspiration for hands-on living®

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Introduction

For years I've wanted to draw my furniture plans in full-size three-dimensional (3D) models. I dreamed of "building" the furniture on the computer as if I were in the shop, shaping each spindle, board, and panel and assembling them into a finished product. Existing two-dimensional (2D) computer-aided design (CAD) systems were okay, but they didn't let me view the project from any angle or check its integrity as it developed. I wanted a design program that gave me exploded views of assemblies, perspective color images, and the ability to ensure that complex joints fit together properly.

Finally, I found what I wanted—Google SketchUp. I've been using this program since 2005 and will never go back to 2D CAD, nor will I enter the shop without first creating a piece in SketchUp.

SketchUp opens up drawing capabilities once available only to professional designers and illustrators using esoteric, expensive CAD systems. Now you can create virtual furniture, using SketchUp to create each piece of wood and hardware, complete with every joint detail. You can view and check every aspect of the furniture with SketchUp's array of viewing options, including easily created exploded and X-Ray views. With SketchUp, you can design furniture full of complex shapes and angles, such as a Windsor chair or a Chippendale lowboy with cabriole legs. Once you have all the components detailed in the model, you can use SketchUp to generate full-size templates for the shop. That makes construction much simpler, faster, and more accurate, with less reworking and fewer delays to sort out discrepancies. You also gain a better understanding of construction details, which pays off when you tackle the real project in the shop.

SketchUp's price is right—free. The no-cost download has all the features you need to produce the most complex woodworking projects and comprehensive shop drawings. A Pro version, priced at $495, includes capabilities and features for importing and exporting files to and from various CAD formats, adding information to models, and producing documents exported in the Adobe PDF format.

Most of the books and tutorials I've seen are designed to help architects, landscape designers, and builders master SketchUp. They aren't always well suited to woodworkers, who use SketchUp in unique ways. That's why I've created this book for professional and hobbyist cabinetmakers, furniture-builders, and designers as well as woodworking teachers. My book will show you how to do the following:

- Develop a complete piece of furniture from scratch or from photos or images imported into SketchUp.
- Create shop drawings, documents, and full-size templates.

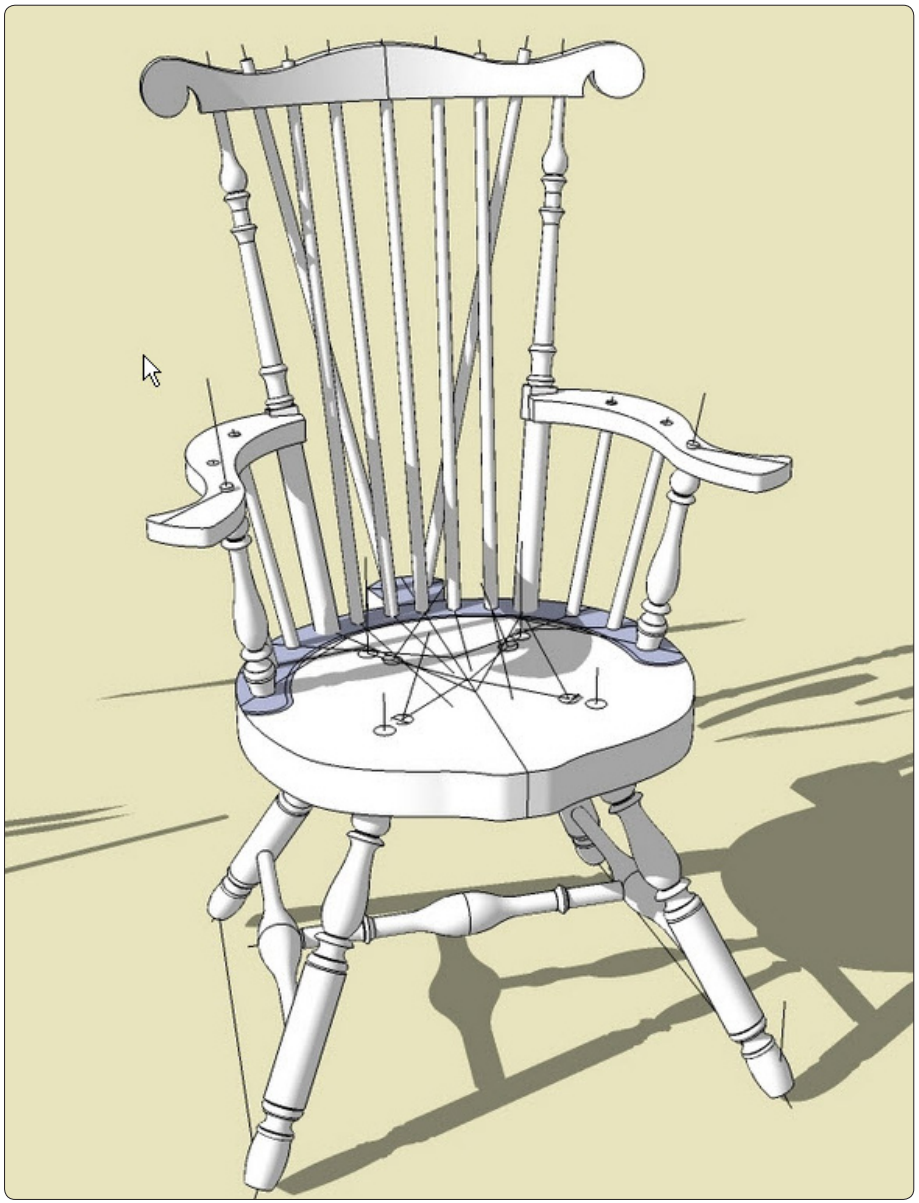


Figure 1. *An assembled view of a Philadelphia fan-back armchair. With SketchUp, even complex pieces like the turned chair legs can be easily created, copied, rotated, and joined to other components.*

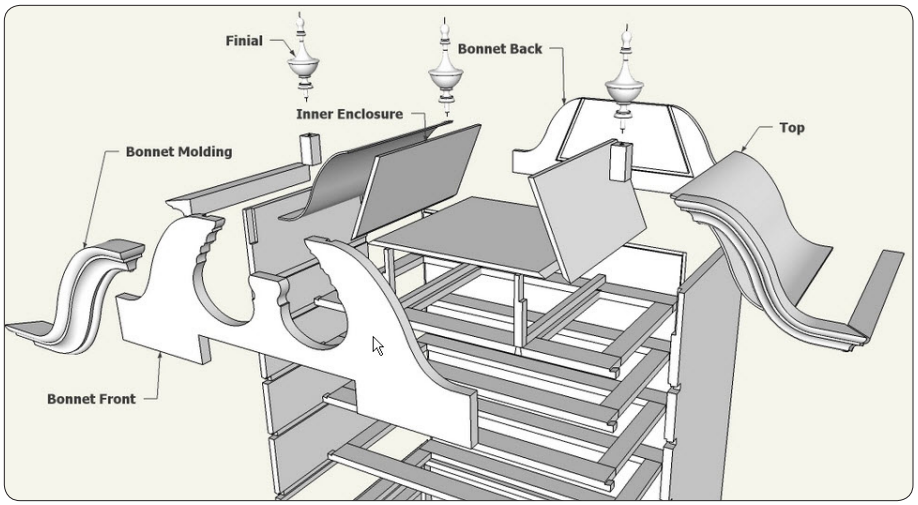


Figure 2. *An exploded view of the top of an American highboy. Once you've drawn the individual elements of a piece of furniture, you can display them in numerous ways without having to redraw anything.*

- Make any woodworking joint, no matter how complex.
- Assemble paneled doors and drawers.
- Shape cabriole legs, back slats, steam-bent parts, scrolled aprons, tapered legs, and the like.
- Design and shape complex moldings.
- Render turned drawer knobs, table legs, chair stretchers, bowls, and spindles.

SketchUp's special strengths (and limitations)

When you work in SketchUp, you create "components." These are 3D elements that define a piece of furniture—a leg, stiles and rails, a drawer front, and so on. For multiples, like table legs and drawer sides, you draw one and copy it as many times as needed. You can rotate or flip the copies to orient them properly. And any change you make to one copy automatically appears in the others.

If you want to reproduce a piece of period furniture, you can import a scanned image of the original into SketchUp, then use the image to determine exact sizes and re-create original shapes.

In SketchUp, there is no need to draw multiple views of an object. With a few mouse clicks, you can view the model or its pieces from any angle and at any size. You can easily create an exploded, orthographic, or X-Ray view.

SketchUp's Scenes feature lets you isolate and enlarge a portion of a large or complex piece, such as a drawer in a highboy, without having to create a separate drawing. Scenes let you generate a complete, detailed, printable design document.

In short, SketchUp allows you to quickly and accurately make a detailed model to generate the dimensional views and full-size templates necessary for basic shop construction.

There are limits to what I can do in SketchUp, however. I learned this when I developed the Maloof-style rocker shown on page 3. I couldn't possibly create a beautifully sculptured chair in SketchUp, but I didn't need artistic sculpturing in the model. What I gained from SketchUp were sizes, angles, joint details, bandsawn shapes, and full-size templates. The final artful sculpturing so important to a Maloof design would have to come from studying photos or an actual piece.

I also bump into SketchUp's limitations on Windsor chairs. SketchUp shows the complex assembly, with parts connected at various angles, but it's not easy for me to render the final shaping and sculpting of the seat, arms, and crest rails. Nevertheless, I would not know how to start a Windsor without first working out all the parts, angles, and connections in SketchUp.

Perhaps someday SketchUp will include a woodworker's toolbox equipped with drawknives, travishers, files, and spokeshaves. Meantime, I'll be quite

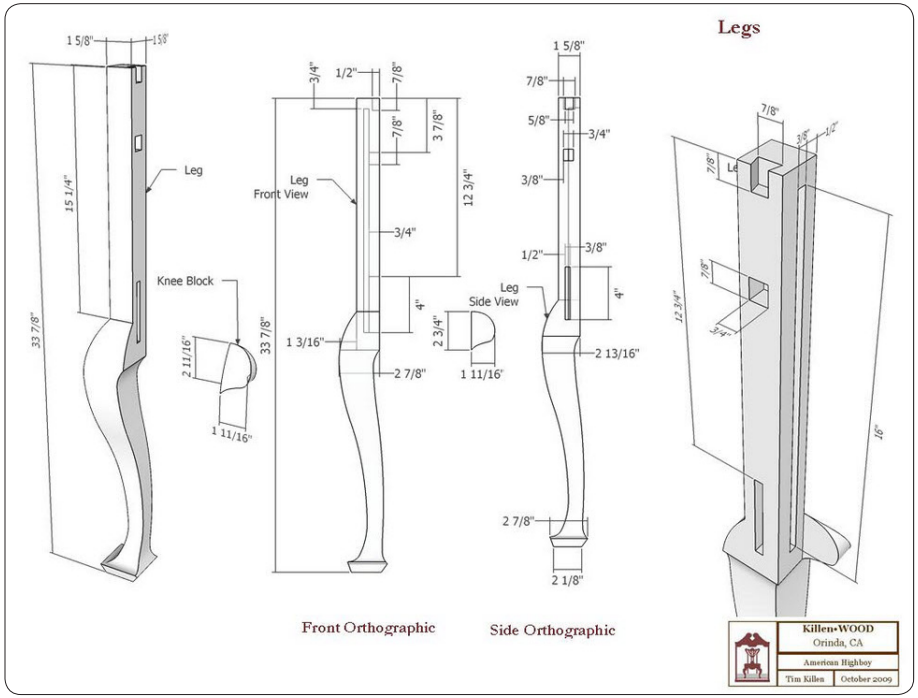


Figure 3. *These drawings of a cabriole leg show SketchUp's versatility. You can show the overall component with dimensions, in two-dimensional views, or in perspective views to show complete details of the joints, such as the dovetail socket and mortises.*

satisfied having SketchUp produce accurate and detailed basic construction information.

What to learn before you begin drawing

Although SketchUp is a remarkably intuitive program, it does have a learning curve. In the years that I've taught woodworkers how to use SketchUp, I've developed a set of beginning steps—what you need before you can begin effectively producing furniture or other woodworking models. I've structured the early chapters of the book to impart the following basic skills.

Setup Covered in Chapter 2, the setup includes which Toolbars to show, how to set up dimensioning so it works best for furniture, and how to have frequently used dialog boxes readily available on the screen. You'll also learn how to save the setup as a template, so that the settings you need are there each time you open SketchUp.

Moving around the model Being able to move around the model is the most important basic skill for a beginning SketchUp user. It's covered in Chapter 3. You'll learn about the three axes that define a 3D view in SketchUp and how to stay on axis so that your drawings are rendered properly. You'll also learn how to pan, zoom, and orbit to move around a model.

How to use basic drawing tools In Chapter 4, you learn the proper ways to use the Line, Polygon, Circle, and Arc tools for drawing basic shapes. I'll also introduce other tools in the SketchUp array. These include the Push/Pull Tool, which adds depth to 2D shapes, and the Tape Measure Tool, which not only lets you check the accuracy of dimensions but also lets you place guidelines to use in drawing components or positioning them accurately.

Drawing to precise length In Chapter 5, I'll take you through the creation of a component—part of the tail vise on a Tage Frid workbench—to show how inputting data using the keyboard lets you draw to exact dimensions. You'll also learn more about using the Tape Measure Tool, the one I use more than any other.

Making, editing, moving, and connecting components A critical feature of SketchUp, described in Chapter 6, makes it possible to treat each piece in the model as if it were a real part of the furniture. Understanding how to create and manipulate components is the key to using SketchUp successfully.

Sure, it can be daunting to learn another computer program. But SketchUp is worth it, especially for woodworkers. It takes work and lots of practice, but you will be amazed at how SketchUp will change and improve your woodworking. It is a powerful tool for your workshop. Learn to use it as if it were a tablesaw, handplane, or router. It can have an effect on your woodworking ability as much as or more than the best shop hardware.

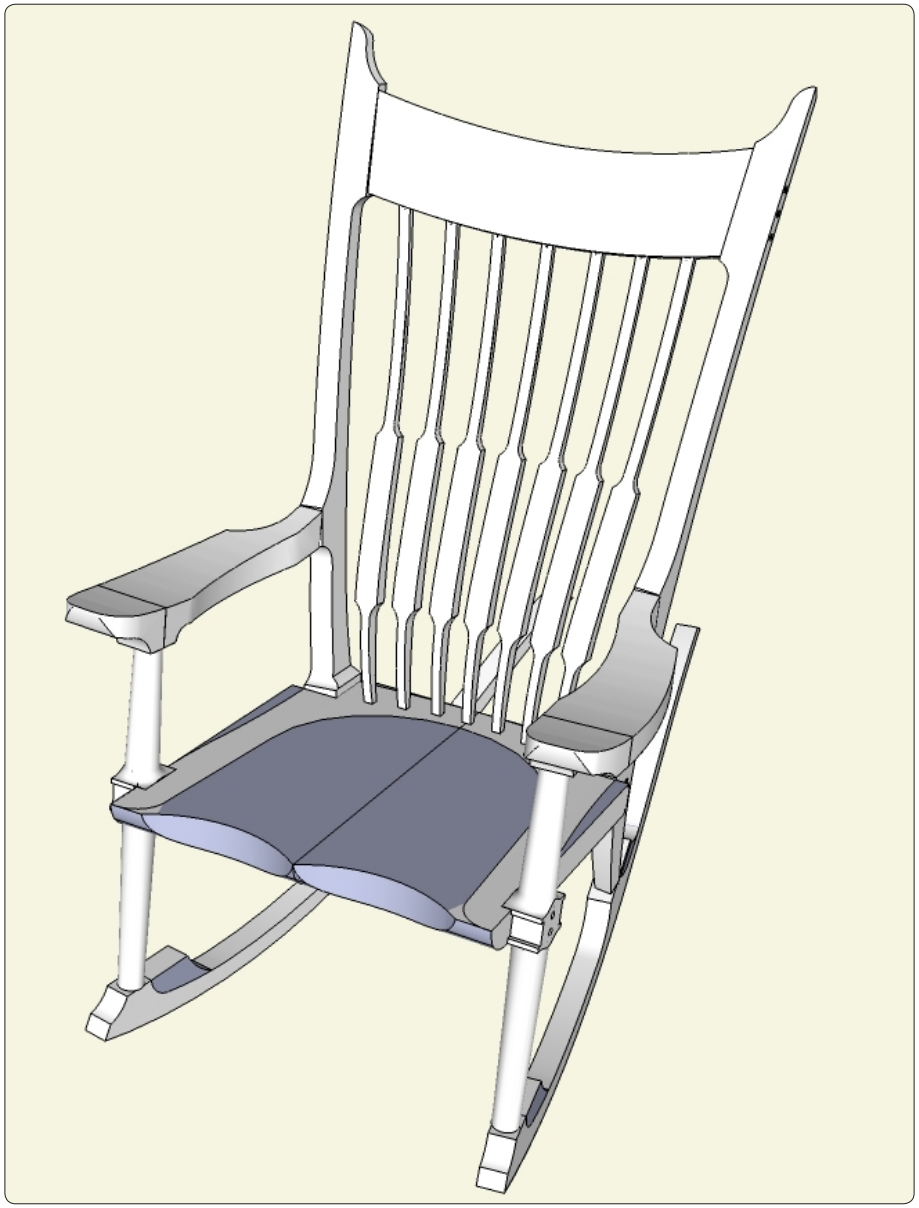


Figure 4. *This rough model of a Maloof-style rocker illustrates SketchUp's limitations. The program is fine for showing joinery and construction details, but not for the artful sculpting that's the hallmark of the Maloof style.*

How to Set Up SketchUp for Woodworking

Downloading SketchUp is straightforward, whether you use Windows XP, Windows Vista, Windows 7, or Mac OS-X. Go to www.sketchup.google.com, the main Google SketchUp website. There, you can choose to download either the Pro version or the Free version. You don't need the Pro version to produce fully detailed models and shop drawings.

The download leaves a SketchUp icon on the desktop. Click on it to open the application and bring up a welcome screen. Click on the Choose Template button. You will see the dialog box shown in Figure 1, which lists the standard templates SketchUp provides. Select Product Design and Woodworking-Inches, which is a good starting point.

SketchUp templates represent default settings available whenever you create a new drawing. You can also create a personalized template by setting numerous other parameters.

Also in the dialog box, uncheck the box labeled "Always show on startup," and click the button labeled "Start using SketchUp." This opens a screen like the one shown in Figure 2. Above the modeling window is the SketchUp toolbar. At the very top of the screen is the Menu Bar with the titles "File," "Edit," "View," and so on.

SketchUp 8

I prepared this book using SketchUp version 7. Shortly before the book was completed, Google released version 8. The upgrade contains a number of changes and new features, but most make it easier to draw buildings or landscapes, not furniture. Other changes appear only in the for-pay Pro version. By and large, SketchUp 8 looks like and works like SketchUp 7, so the instructions in this book still apply.

SketchUp 8 has a couple of interesting new features that should appeal to woodworkers. The Scenes dialog box now displays thumbnail images of each scene you create. (See chapter 15 for more on scenes.) There is a new face style, called Back Edges. It shows hidden edges of an object as dashed lines. It's an alternative to the frequently used X-Ray face view (see chapter 3). In orthogonal views, the Back Edges view also makes the sketch look more like conventional mechanical drawing, with dadoes, grooves, and other hidden elements rendered in dashed lines.

I recommend making the following changes and saving them within a personalized template.

Set the Model Information

Model Info fixes the units of measurement you'll use, the degree of precision in the measurements, and the appearance of on-screen numbers and words.

1. Click on the Window tab in the Menu bar to open the drop-down dialog box shown in Figure 3.
2. Click on Model Info in the dialog box to open a new dialog box, as shown in Figure 4.
3. In the window on the left of the Model Info dialog box, click on Units. Then, using the other windows in that dialog box, set the Format to Fractional, the Precision to 1/16", and check the box

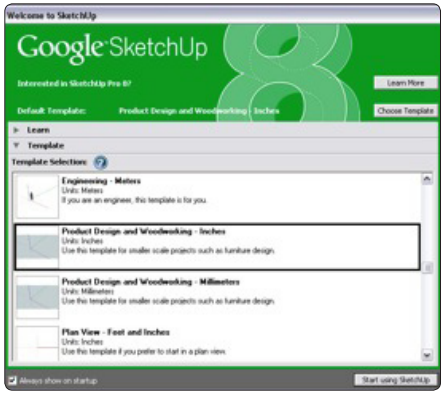


Figure 1. *The Welcome to SketchUp dialog box.*

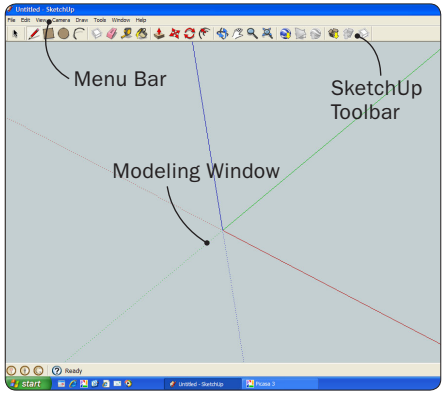


Figure 2. *The opening screen.*

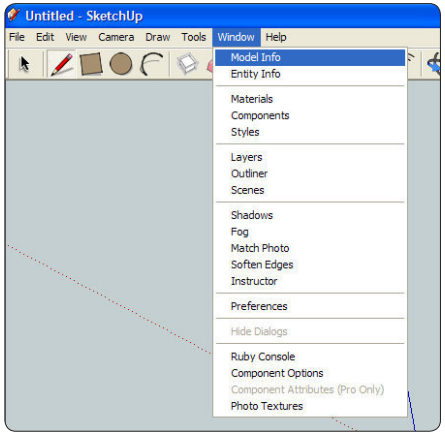


Figure 3. *The drop-down dialog box in the Windows menu.*

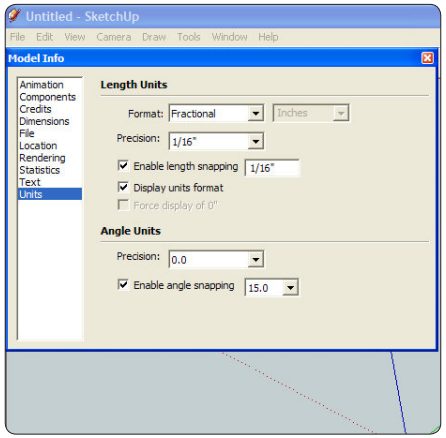


Figure 4. *The dialog box for setting units of length.*

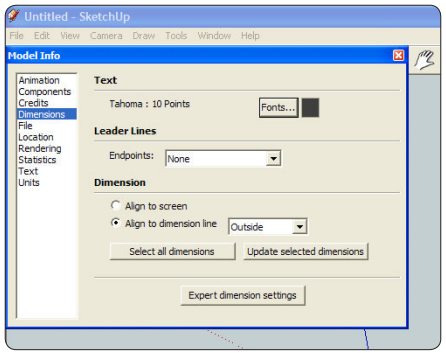


Figure 5. *The dialog box for setting the size and style of dimensions and labels.*

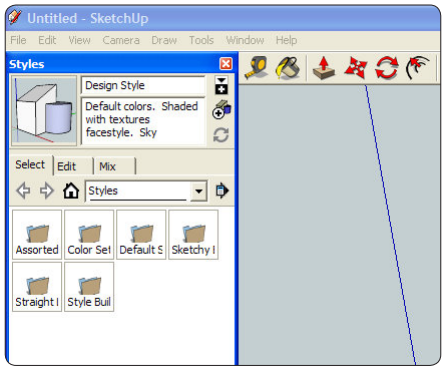


Figure 6. *The Styles dialog box.*

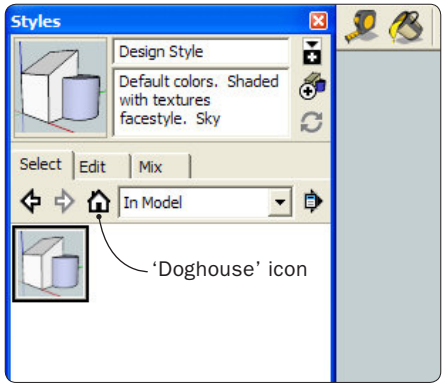


Figure 7. *Clicking on the icon shown opens this dialog box.*

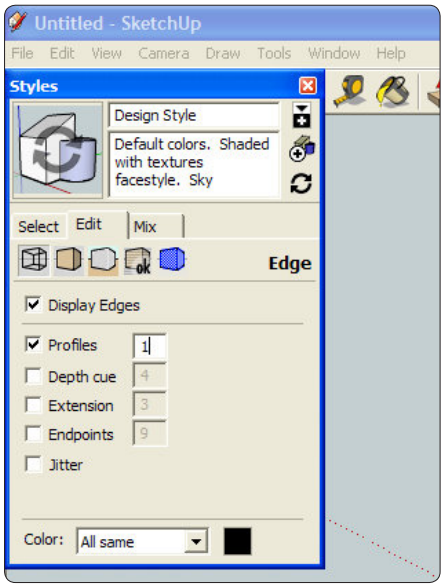


Figure 8. *The Edge Styles dialog box.*

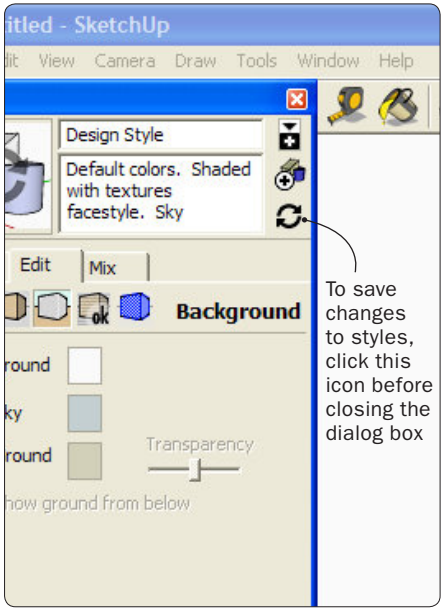


Figure 9. *The Background Styles dialog box.*

labeled Enable Length Snapping. The 1/16-in. setting is adequate for most woodworking tasks, but you can change the setting to 1/32 in. or 1/64 in. at any time if you need greater display precision.

4. Click on Dimensions in the window on the left of the Model Info dialog box (Figure 5). Set Fonts to size 10 and Leader Lines Endpoints to None. Choose the label Align to Dimension Line Outside.

Set the Styles

Style settings determine the background color in your drawings, the weight of the lines that form the edges of objects in the drawings, and the colors of the objects you draw.

1. Click on the Window tab in the Menu bar to open the drop-down dialog box. Choose Styles to open a new window, as shown in Figure 6.

2. Click on what I call the doghouse icon (Google calls it the In Model icon) near the center of the window. That causes the dialog box to change as in Figure 7, showing the current style below the doghouse icon.

3. Click the Edit tab in the window. This brings up five small icons and some new windows, as shown in Figure 8.

4. Click on the leftmost icon, which represents Edge Styles. In the small boxes below, check the Profile box and place a 1 in the adjacent box. This setting gives an edge weight that's not too thick and not too thin.

5. Click on the Background icon, which is the one in the center, to bring up choices for the background, as shown in Figure 9. Leave the boxes for Sky and Ground unchecked. Click on the

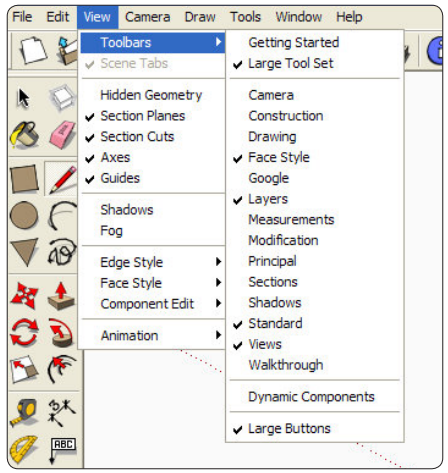


Figure 10. *The Toolbars choices in the View menu.*

Background box to fix the background color: Set the RGB values to 250, 250, 250, which is very close to a pure white background. (I like a slightly off-white background to contrast with the white faces in the model.)

6. Click on the Update icon (the icon with two half-circle arrows chasing each other) in the upper-right corner of the window, to save your changes. Always click that icon before closing the box.

I've skipped over several of the options, focusing instead on the default values. As you gain experience with SketchUp, you'll want to learn more about and experiment with those other options.

Set the Toolbars

Toolbars set up the SketchUp screen so that the tools you use most often are always in view.

1. Click the View tab on the Menu Bar and point your mouse over the Toolbars item at the top of the list. (If you are

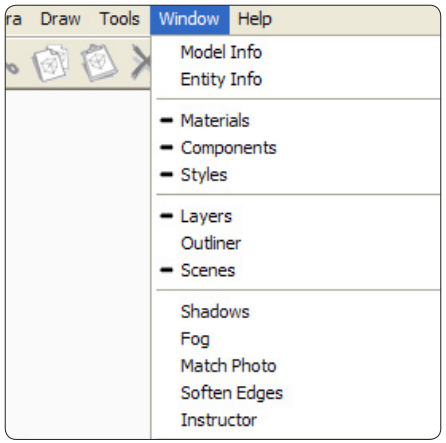


Figure 11. *The heavy dashes next to entries in the drop-down menu identify dialog boxes to be shown on the screen.*

on a Mac, click on View, choose Tool Palettes, then Large Tool Set.) On the Windows version, you will see a pop-up list as shown in Figure 10. The window looks slightly different on the Mac, but still offers the Large Tool Set.

Checkmarks in the pop-up menu identify my recommended toolbars: Large Tool Set, Face Style, Layers, Standard, Views, and Large Buttons. Each of these toolbar modifications is made independently. That is, for each change you must click the View tab, hover over Toolbars, and click on one of the toolbars in the list. Leave the Getting Started toolbar unchecked because other settings incorporate those tools. On the Mac, choose these same sets of tools, but drag and drop them from the Tool Palette to the screen.

Set the Dialog Boxes

The last setup step involves placing frequently used dialog boxes on the screen in a "minimized clump" format. I like to have Materials, Components, Styles, Layers, and Scene dialog boxes readily available on-screen. These are all available in the Window drop-down menu. As shown in Figure 11, a heavy dash identifies those items in the drop-down list. Like individual toolbars, dialog boxes are placed one at a time.

1. Click the Window tab on the Menu Bar, then click on Materials in the drop-down list to open the Materials dialog box, as shown in Figure 12. (The box looks quite different on a Mac.)

2. Tap the mouse on its top title bar. That reduces the box to the size of the title bar only. To expand the box, tap the title bar again.

3. Open another dialog box, minimize it, then move it by grabbing the top title bar with the mouse and dragging it to connect to the others. Do this for each box you want to display. This forms a clump of dialog boxes that can be moved around the screen to avoid interfering with the drawing space. Figure 13 shows the five dialog boxes minimized and clumped.

Save the Changes as a Template

Save the changes as a template. This very important step ensures that your personalized settings will appear each time you open SketchUp. Creating a template is simple.

Click the File tab in the Menu Bar. In the drop-down menu select Save As Template, as shown in Figure 14. This opens a new dialog box, as shown in the inset to the figure. Fill out the template form with the name and description you prefer and click Save.

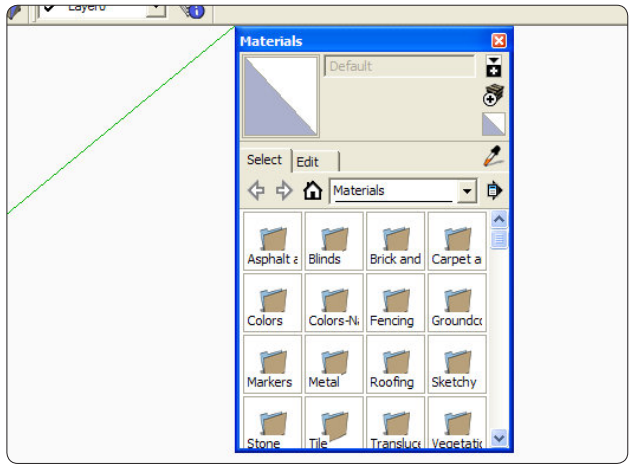


Figure 12. *The Materials dialog box. To minimize it, click on the heavy top bar.*

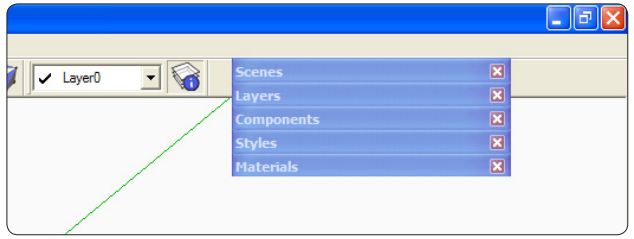


Figure 13. *The dialog boxes minimized, clumped, and positioned where they won't interfere with the drawing.*

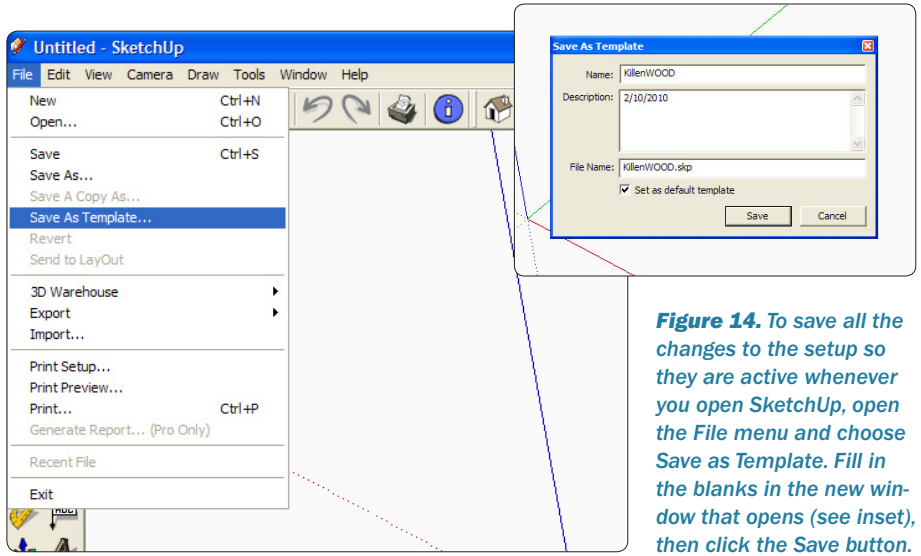


Figure 14. *To save all the changes to the setup so they are active whenever you open SketchUp, open the File menu and choose Save as Template. Fill in the blanks in the new window that opens (see inset), then click the Save button.*

The Modeling Environment and Toolbars

Before you begin to draw in SketchUp, you need to learn the basics of the modeling environment and how to move around within it.

There are many ways to maneuver around in SketchUp, including dedicated tools and shortcut keys. But in my experience, the best way to get around is with a mouse that has a scroll wheel. Even if you have a laptop with a touchpad, it will pay to get a good mouse with a scroll wheel and use it.

The axes

When you open SketchUp, you'll see the screen shown in Figure 1, with red, green, and blue axes connected at an origin. The red axis follows the X direction (left to right), the green axis follows the Y direction (from front to back), and the blue axis follows the Z direction (up and down).

As you model and move around in SketchUp, the axes and the origin are often out of view, but you always need to keep in mind how the axes are aligned. Fortunately, SketchUp automatically helps keep you properly oriented by highlighting an axis color when you use one of the drawing tools. For example, when you begin drawing a line without regard to its axis, the line will appear black, but when you get the line oriented along, say, the X axis, the line will change to red.

How to move around the model

There are three basic movements in SketchUp: zoom, orbit, and pan.

To use the Zoom Tool, rotate the scroll wheel on the mouse. Roll it toward the nose of the mouse to zoom closer to the model; roll it toward the tail of the mouse to zoom away.

The Orbit Tool rotates your view of the model around one or more of the axes. To use the Orbit Tool, press the scroll wheel as you move the mouse. Moving the mouse left to right rotates your view clockwise (as if the model were rotating counterclockwise), moving the mouse right to left spins your view counterclockwise, and moving the mouse forward and back rotates your view up and down. Moving the mouse on a diagonal will rotate your view in two directions.

The Pan Tool moves the view from side to side or top to bottom without changing the model's orientation. I pan often to center my model on the screen. To pan, hold down the mouse scroll wheel while pressing the Shift key as you move the mouse left, right, forward, or back.

Figure 2 shows SketchUp's on-screen tools for moving around the model. The Zoom Extents Tool makes your entire model visible and centered on the screen. Occasionally, you may lose your model because it seems to vanish from the screen. No amount of panning and zooming can bring it back. But one click of the Zoom Extents Tool automatically brings the model back in view.

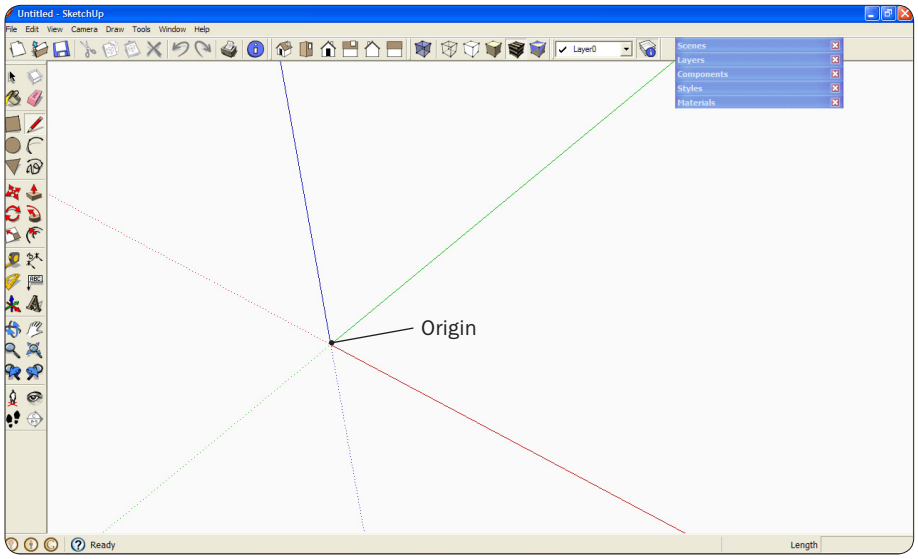


Figure 1. *SketchUp's opening screen, showing the red, green, and blue axes.*

Zoom Extents is a very useful tool. As for Zoom, Orbit, and Pan, I think it's better to ignore them and use the mouse instead. Using the tools makes modeling inefficient, slowing it to an unacceptable level.

When you depress the scroll wheel, the mouse pointer changes to the Orbit icon. When you press the scroll wheel and the Shift key, the pointer changes to the Pan icon.

To help you become familiar with the modeling environment, the move tools, and the like, I'm providing a SketchUp

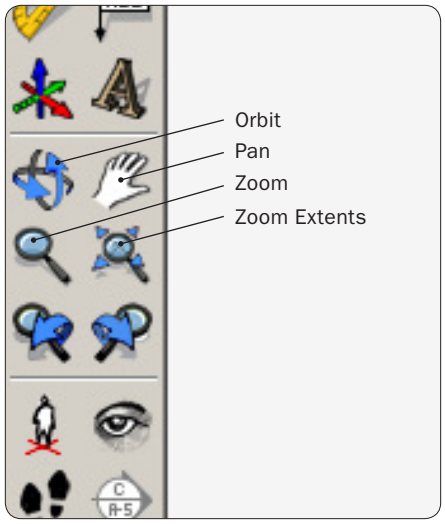


Figure 2. *The four tools that allow you to move your orientation with respect to the model. Although you can click these icons on the toolbar, it's faster to use the mouse to activate the Orbit, Pan, and Zoom Tools.*

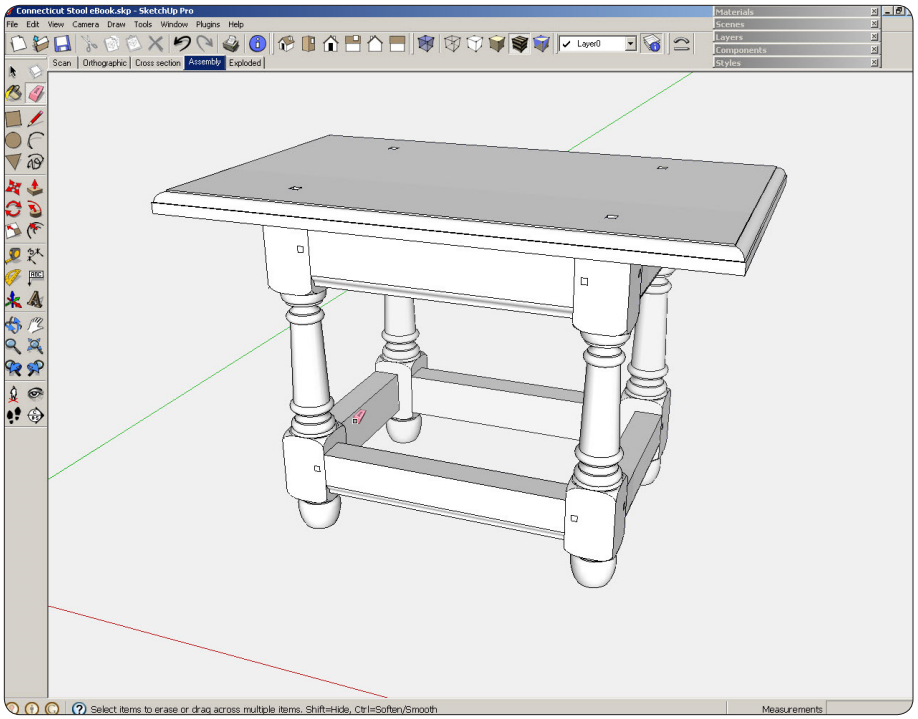


Figure 3. *You can download the SketchUp file for the Connecticut stool to help you become familiar with SketchUp's tools and the modeling environment.*

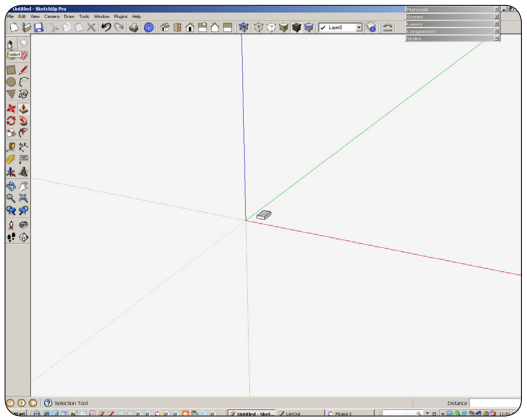


Figure 4. *Zoomed out to a "fly speck."*

Figure 5. *The horizontal toolbars let you change the point of view of the drawing, alter the style of the faces in a model, and perform such basic functions as cut, copy, paste, and print.*

file of the Connecticut Stool shown in Figure 3. Open the SketchUp file provided with this book. Use the file to practice moving around the model with the mouse to orbit, zoom, and pan. For example, zoom into the corner of the top to inspect the thumbnail molding, or drive into the leg to get a close-up of the round-to-square transition.

As I'll show later in the chapter, you can also use the file to familiarize yourself with SketchUp's toolbars. As you try out the movement tools, you will find that it's easy to zoom out quickly to a very tiny block that's extremely hard to see (Figure 4). Obviously, it's difficult and frustrating to edit and work on a model the size of a fly speck. Fortunately, it's easy to fix the view by zooming and positioning the model with Orbit and Pan.

Why use a mouse?

The benefits of using a mouse can be simply put: A mouse lets you multitask. You can be drawing a line, moving a component, or copying it while simultaneously moving around the model. There is no need to stop one activity and switch tools when you want to shift your view of the model.

When designing a piece of furniture, you often have to connect components precisely. So as you move one component into position, you zoom in to be sure you're making the right connection. And you may need to orbit the model to get a better view. These viewing actions can be done while the Move/Copy Tool is still activated. You can go back and forth quickly between changing the view and moving the component.

One caution: Mice come with a disk or download instructions for installing specific drivers. However, the default settings in those drivers make the scroll wheel implement odd actions, such as opening Internet Explorer. When I buy a new mouse, I don't bother with the drivers. Instead, I let my computer's operating system handle the defaults.

Horizontal toolbars

In Chapter 2, you learned how to place various toolbars in a horizontal row across the top of the screen, as shown in Figure 5. This section covers the specific tools in more detail and explains which ones I find most useful. If you forget

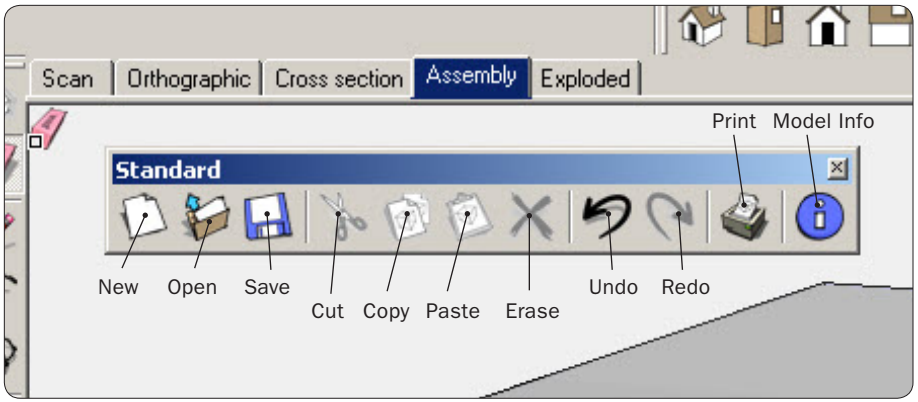


Figure 6. *The Standard Toolbar includes functions common to many computer applications.*

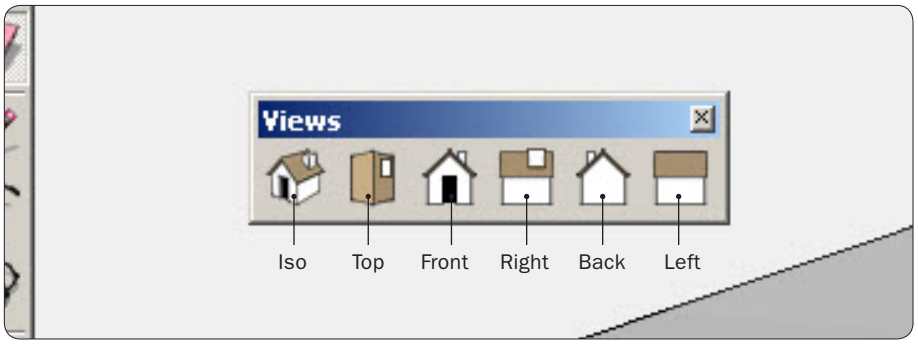


Figure 7. *The Views Toolbar lets you change the orientation of the model with one mouse click.*

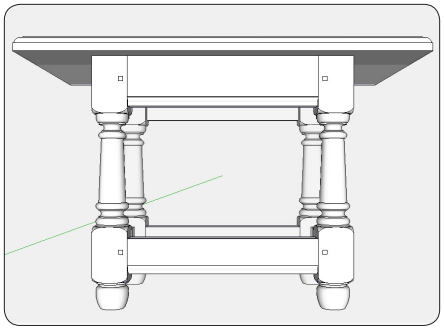


Figure 8. *Clicking the Front icon in the Views Toolbar gives you a head-on perspective view of the object you are drawing.*

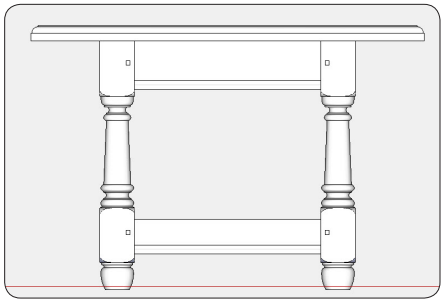


Figure 9. *When you choose the Front view and select Parallel Projection from the Camera menu, you get a 2D head-on view. It's very useful for producing full-size templates.*

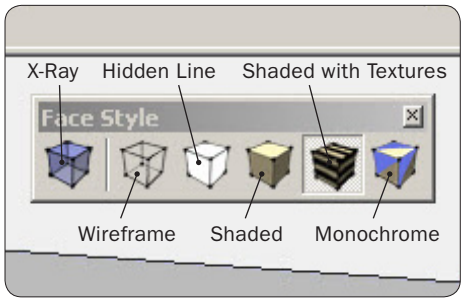


Figure 10. *The Face Style Toolbar lets you alter the appearance of the drawing. Of the six choices, I use only the X-Ray and the Shaded with Textures styles.*

what function or tool an icon activates, just place your mouse over the icon; that will make the tool's name appear.

Standard Toolbar

Figure 6 shows the Standard Toolbar pulled down from its normal position, but only for the sake of clarity. The icons identify functions that are common to many computer applications: Cut, Copy, Paste, Print, Undo, Redo, and the like. The Mac version lacks the Standard Toolbar, but you can pick the Undo/Redo Toolbar, which is very helpful.

The Undo and Redo buttons are especially helpful in SketchUp. I probably use Undo more than any other function. You'll often experiment with lines, arcs, movements, copies, and other actions. Clicking the Undo icon makes it easy to go back to the starting point.

Views Toolbar

Figure 7 shows the Views Toolbar. The six icons represent standard views in SketchUp and let you reorient the entire model with one mouse click.

For example, when you click on the Front icon, SketchUp automatically positions the model as if you were looking straight at it from the front in a perspective view (Figure 8).

I use these standard views because I like to have front, side, and top orthographic views for reference. They can also be faster than the Orbit Tool for maneuvering to the side of the model. However, I do not use the isometric view because I prefer the normal SketchUp perspective.

You can also use the View icons in conjunction with choices found in the Camera tab in the Menu Bar. For example, begin with the stool shown from the front in a standard perspective view. Now click on the Camera tab and choose Parallel Projection from the drop-down menu. You'll see that SketchUp changes the view of the stool to a front orthographic (2D) view, as shown in Figure 9. This type of view is essential for producing full-size templates. I'll discuss that in more detail in Chapter 16.

Practice selecting various standard views from the View Toolbar and experiment with Perspective and Parallel Projections from the Camera menu.

Face Style Toolbar

The six icons in the Face Style Toolbar (Figure 10) determine the appearance of

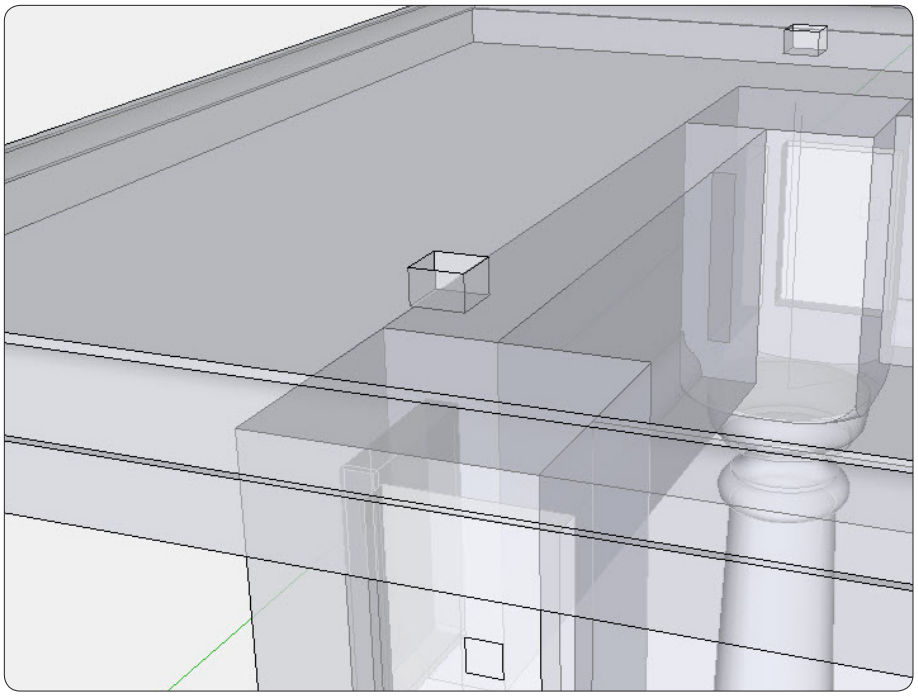


Figure 11. *An X-Ray view is the easiest way to see how accurately you've drawn joinery. If a tenon doesn't fit precisely in its mortise, for example, you'll see the problem right away.*

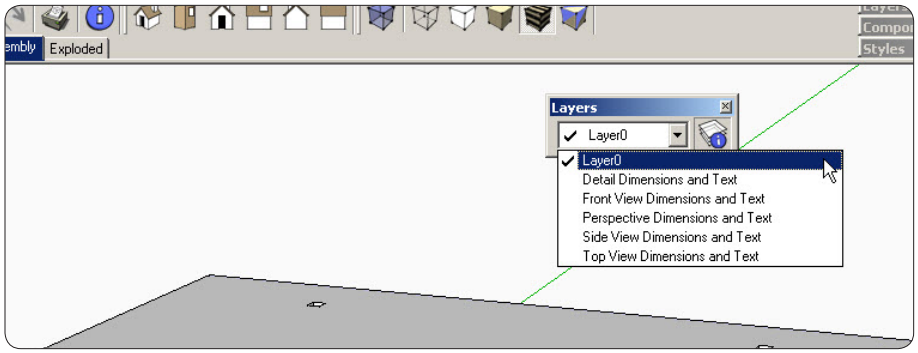


Figure 12. *The Layers Toolbar is useful when you want to have multiple views of an object.*

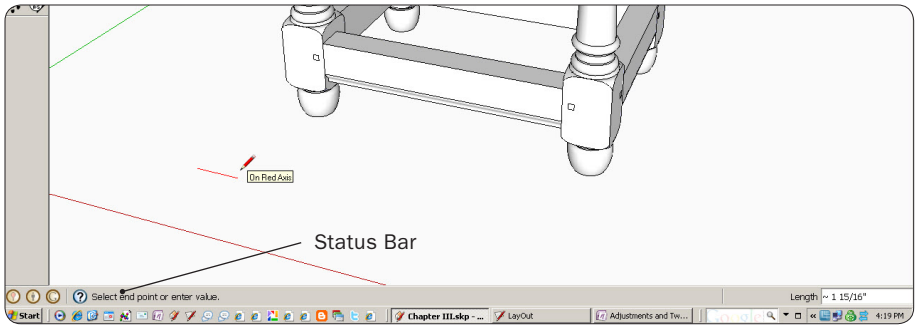


Figure 13. *The Status Bar provides helpful hints and tutorials on using SketchUp's tools.*

the faces of the model. The default face style is the second from the right: Shaded with Textures. I find it effective for most of my modeling. The only other face style I use is X-Ray, on the far left. Figure 11 shows the stool in X-Ray view, making the mortise-and-tenon joints visible. I use X-Ray often to check my joinery. For example, if a tenon is not sized or positioned properly, the X-Ray view will clearly show the problem. I also use X-Ray when I print full-size templates. The template shows the hidden joinery, which helps me mark joint locations on the wood.

I ignore the other four face styles because I don't find them useful for my woodworking. However, click on each of the icons to see how they change the appearance of the drawing.

Layers Toolbar

As you begin to learn SketchUp, ignore the Layers tools. Although CAD programs typically require the use of different layers, SketchUp doesn't. I'll cover layers and how to use them in Chapter 15.

Layers represent alternative ways of viewing the object you are drawing. I use layers to produce a package of drawing documents, isolating features or dimensions to particular scenes. As Figure 12 shows, when you open the Layers Toolbar and click the arrow to the right of the Text Box, you open a pop-up box listing all the layers you have created. In this case, the Connecticut stool model has five layers. Layer 0 is the default layer. By creating separate layers, I can have dimensions and text show up in one view but not in others. If you use layers, keep the default layer as 0, otherwise you may unintentionally create graphics on another layer that will cause problems when you set up views (Scenes) and produce drawings.

Check the status bar

The Status Bar is always displayed at the bottom of the SketchUp screen. It provides a significant amount of good information. As you model—choose tools, move components, and so on—the Status Bar updates with instructions or options for your next steps.

As you can see in Figure 13, I have begun to draw a line, identified by the small Pencil icon in the foreground. The Status Bar says, "Select endpoint or enter value." That is, it's suggesting my next step in finishing the line. The Status Bar also provides Status Indicator icons, which you can click to get help. When you select a tool and click the Question Mark icon, for example, an Instructor Dialog Box opens to explain how the tool works.

How to Use Basic SketchUp Tools

Figure 1 shows the Large Tool Set, which includes all the drawing, moving, measuring, labeling, and viewing tools. When you hover the mouse over an icon in the tool set, SketchUp identifies the tool with a small label, like the one for Line Tool in the illustration.

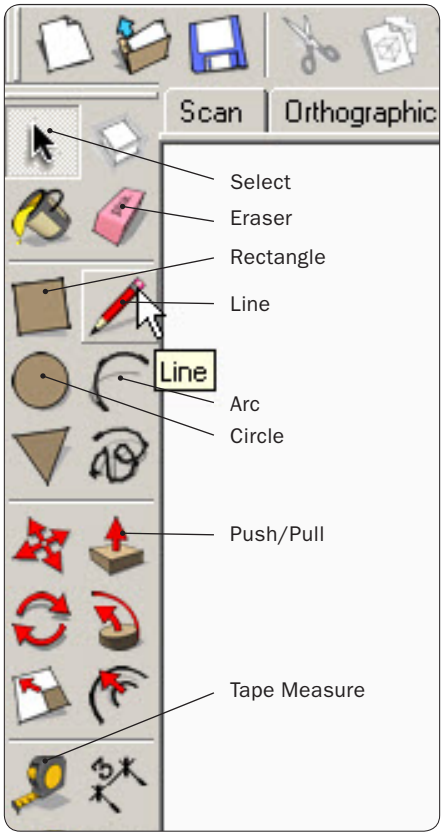


Figure 1. *Drawing tools in the Large Tool Set.*

I'll cover the following eight tools in this chapter:

Line Tool. Used to make straight lines or create a plane-like face for a piece of wood. Another tool pushes or pulls the face to the desired thickness.

Eraser Tool. This tool does just what its name says. But it also allows you to hide or smooth parts of the model by removing odd facets and lines.

Push/Pull Tool. Probably the most frequently used SketchUp tool. It transforms a plane or face into a 3D object. The Push/Pull Tool allows you to make mortises and tenons and to make or change the thickness, width, or length of a piece of wood.

Select Tool. This is used to pick individual parts or the complete model. Once you select a part it can be deleted, moved, copied, or scaled, using other tools in the set.

Rectangle Tool. It draws a four-sided shape. I don't use this tool, but I've included it because I know many woodworkers who do use it effectively to begin drawing pieces of wood.

Circle Tool. Used to make round components like dowels or holes for tenon pins, screws, bolts, and such.

Arc Tool. Used for the shapes in moldings, lathe turnings, knobs, carvings, and the like.

Tape Measure Tool. You use this tool to check dimensions. The Tape Measure Tool also lets you place temporary construction lines to show the location of holes, dovetails, joints, cuts, grooves, and so on.

You need to become familiar with these tools before moving on to the others in the Large Tool Set. I'll explain how to use the other tools in later chapters.

The Line Tool

Click on the Line Tool. The cursor will take the shape of the Pencil icon.

Begin drawing a line by clicking the left mouse button in the modeling window, close to the origin of the three axes. Where you click sets the starting point for the line. Click the mouse button to start the line and release the button immediately—do not hold it. Drag the mouse from left to right to extend the line to the right. As you can see in Figure 2, the line will be red. That means the line is being drawn on the red axis. If you don't see a red line, move the mouse slightly until the line snaps onto the red axis. So far, the line is "rubber banding," and its direction and length depend on how you move the mouse.

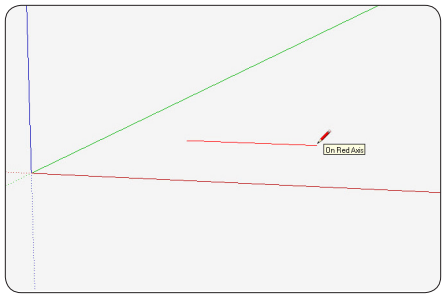


Figure 2. *The beginning of a line drawn along the red axis.*

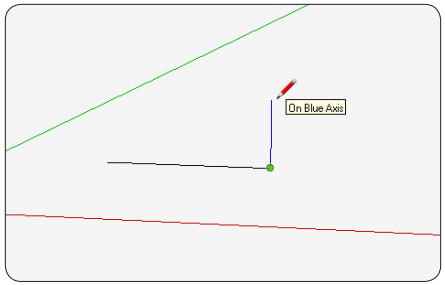


Figure 3. *A line along the blue axis.*

Make the line any length you wish, checking to be sure it remains red, then click the mouse button to set its endpoint. When you click to end the line, its color will change to black.

SketchUp assumes that you will continue to draw a line from the end of the previous line, so you don't need to click the mouse button to continue drawing. The Line Tool continues rubber banding until you click the mouse again, select another tool, or press the Esc key.

Continue drawing the line, but shift its direction to the blue axis. Move the mouse as needed to ensure that the line color is blue. Click the left mouse button to set the end of this line (Figure 3).

Continue drawing the line, keeping it on the red axis again and moving the mouse from right to left to draw the line toward the left. When the cursor reaches a spot just above end of the first line you drew, a dotted line will appear. This is an inference—SketchUp's anticipation of your next step. In this instance, SketchUp believes you intend to make a rectangle, so it automatically indicates the point at which you should end the line. Click the mouse to end the line at the inference point, as shown in Figure 4. There are occasions when SketchUp balks at showing the inference and needs some help to find it. You can help by touching the first line's endpoint, then dragging the mouse to line up with the axis.

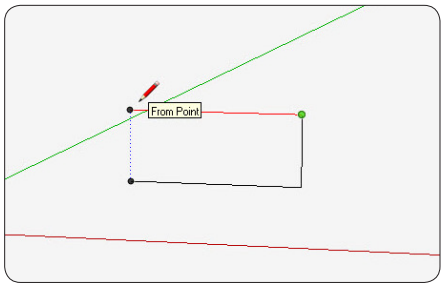


Figure 4. *Drawing another line along the red axis and creating an inference, shown by the vertical dotted line.*

Continue the line along the blue axis back to the starting point of the first line. Click the mouse to end the line. The rectangle immediately fills with a white "face," as shown in Figure 5. Everything drawn in SketchUp is composed of edges and faces. The lines you create make up the edges, and since the edges exist in one geometrical plane (coplanar), SketchUp automatically fills in a face.

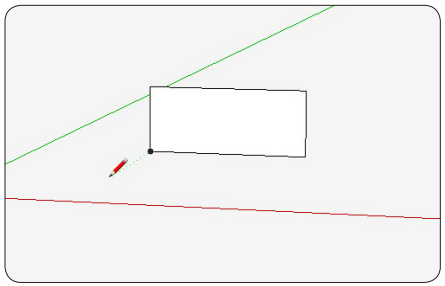


Figure 5. *Completing the rectangle. SketchUp automatically fills in the space to create a face.*

Faces indicate drawing quality. If a face does not appear when you expect it to, chances are the lines you drew are not coplanar, meaning that one or more lines weren't on axis.

Next, you'll give this one face some thickness. If you were designing a piece of furniture, this would become its first piece of wood.

Be sure you still have the Line Tool selected. Click the mouse on the lower end of the rectangle, then release the mouse button immediately. Be sure the line is on the green axis (the line will turn green), and maneuver the mouse so that the line moves toward the background. Click to end the line, as shown in Figure 6.

Continue the line upward on the blue axis. When the inference appears, click the mouse button to end the line.

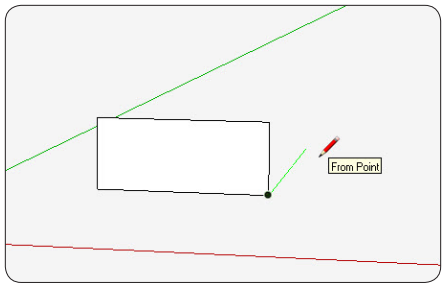


Figure 6. *Starting a line along the green axis, to begin creating a 3D object.*

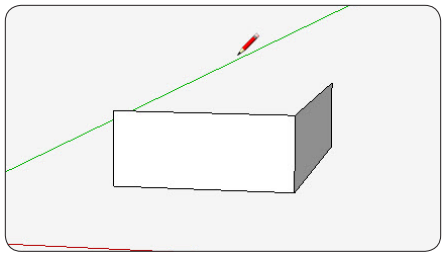


Figure 7. *Closing in one side and creating a second face.*

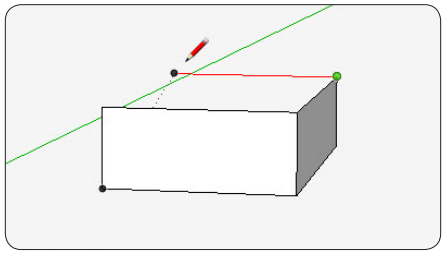


Figure 8. *Creating the top edges.*

Draw a line back to the upper right hand corner of the original face. Another end face appears automatically, as shown in Figure 7.

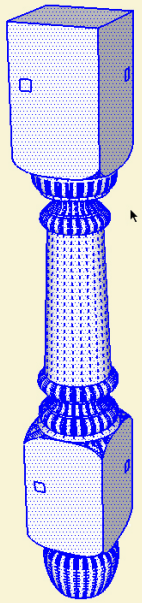
Draw a line toward the left on the red axis until you see an inference. In this case, the inference will appear as a dotted diagonal line. Click the mouse to end the line, as shown in Figure 8.

Edges and Faces

The SketchUp computer geometry is rather simple—all components and pieces are composed of edges and faces. Here you see the Connecticut stool leg with all of its edges and faces selected, which highlights them in blue. Although in SketchUp we see the leg as a solid, it is actually hollow. It's an object with a thin (zero thickness) skin of faces surrounded by edges.

All edges in SketchUp consist of straight lines only. Even curved edges, such as the turned portions of the stool leg, are made up of many straight lines—so many that the curves look smooth. But if you zoom in close, you can see the straight line segments in the curves.

Faces are also always flat. The turned surfaces in the leg are made up of many very small flat faces. You need connecting edges on a common plane to achieve a face. You can't make a face in SketchUp without creating edges that make up a plane. There isn't a Face Tool in SketchUp. Rather, to create a face you create edges. If they are copolanar, SketchUp automatically fills in the face.



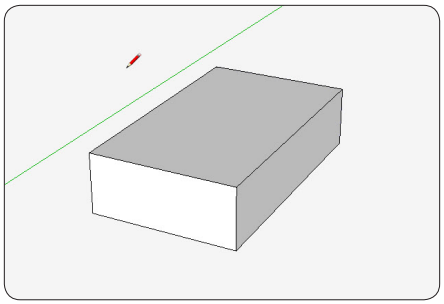


Figure 9. *Finishing the block.*

There are easier ways to draw rectangular blocks—pieces of wood, if you will. You'll learn those techniques later. But drawing the block one line at a time helps you understand how to use the Line Tool, how to stay on axis, and how to make use of SketchUp's inferences.

Whenever you want to stop SketchUp from continuing to draw a line, hit the Esc key. That cancels the action altogether, so you can begin anew.

Figure 9 shows the finished block, completely enclosed with six faces. Use the mouse and scroll wheel to zoom in and orbit around. Check out the bottom face by orbiting downward. Then orbit around the block to look at the back face.

Put your cursor over the block and practice zooming in and out with the mouse scroll wheel. Note that when you zoom, the position of the block on screen depends on where you positioned the mouse cursor. When the cursor is over the block, it will remain in the center of the screen. Try moving the mouse to the upper-right hand corner. Now when you zoom in, the block will move off the screen toward the lower left corner.

Creating this block is an important initial exercise. It introduces you to the basic drawing features in 3D space. It also lets you practice six points to remember for successful modeling:

- Use the mouse correctly. Click the left button; don't hold it down.
- Release the mouse button before dragging the mouse.
- Stay on the red, green, or blue axis.
- Watch for the inferences that SketchUp automatically displays.
- Zoom in as close as you can to the model, so you can easily see what you're doing.
- Use Pan, Orbit, and Zoom as often as needed to get a convenient view of the model.

The Eraser Tool

One of the most frequently used tools is the Eraser.

Select the Eraser Tool and move it so that the small square on the end of the tool is over one of the block's edges. Click the mouse to delete the edge. The faces that were dependent on that edge are also deleted.

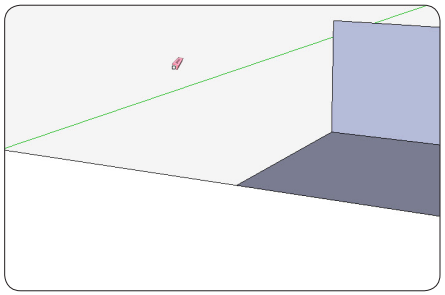


Figure 10. *Using the Eraser Tool to remove an edge from the block.*

Position the small square at the end of the Eraser Tool on a corner of the block. This time, when you click the mouse, multiple edges and faces disappear (Figure 10). You can also hold the mouse button and drag the Eraser Tool to delete lines and faces. When you hold down the mouse button, the lines you want to erase turn blue.

Use the Eraser Tool to delete edges, but leave the front face intact. You'll do more with that face in a later step.

The Eraser Tool performs a couple of other handy functions, which I will cover in more detail later. In combination with the Shift key, the Eraser Tool will temporarily hide selected graphics, a component, a line, or a face from view. To "unhide," or bring the graphics back into view, click on Edit in the Menu Bar and select Unhide from the menu. When combined with the Ctrl key (Option on a Mac), the Eraser Tool becomes a smoothing and softening tool to remove hard lines that should not show.

The Push/Pull Tool

In an earlier step, you made the block a 3D object by adding lines with the Line Tool. There is a much easier way to accomplish that: Use the Push/Pull Tool.

Click on the tool and move the cursor over the front face of the block. A pattern of small blue dots appears on the face, as shown in Figure 11. Click and release the left mouse button. Now move the mouse in the green direction, toward the background. As you move the mouse, the face—now a 3D block—grows longer, as shown in Figure 12. To end the extrusion,

Use the Arrow Keys to Stay on Axis

SketchUp has two ways to help you stay on axis.

1. Use the four arrow keys on the computer keyboard. Tapping the appropriate key when you begin to draw a line constrains the line to a particular axis. For example, if you need to draw a line on the red axis, click the mouse to start the line, then tap the Right Arrow key. No matter what direction you move the mouse, the line will follow the red axis. To constrain the line to the green axis, tap the Left Arrow key. To constrain the line to the blue axis, tap either the Up Arrow or Down Arrow key.

The arrow keys also work with the Move/Copy Tool. To constrain movement of a component on the red axis, for example, tap the Right Arrow key. Use the other arrow keys to constrain movement on the other axes.

2. Use the Shift key. In this case, you need to start the line or the movement on the desired axis, then hold down the Shift key. This will constrain the line or movement on that selected axis. You will find these aids invaluable. I use them very frequently.

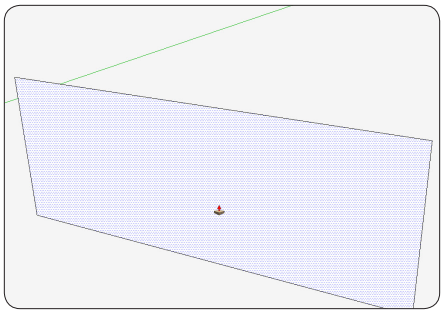


Figure 11. *Hovering the Push/Pull Tool over a face selects it, as shown by the pattern of blue dots.*

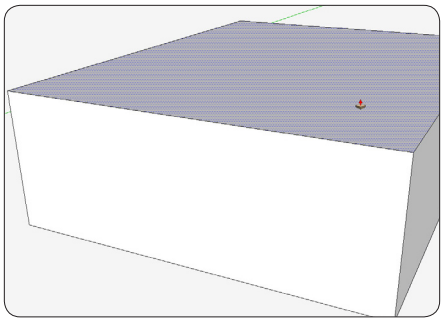


Figure 12. *Using the Push/Pull Tool to give thickness to a rectangle.*

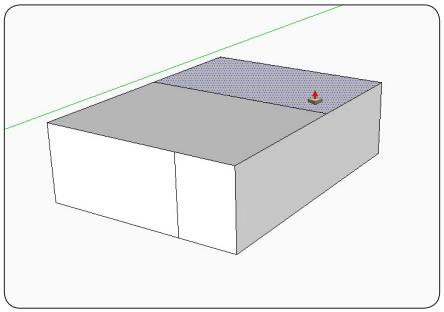


Figure 13. *Adding lines breaks faces and their edges into separate elements. Here, the line divides one face, so that only part is selected.*

click the mouse button again. Experiment with the Push/Pull Tool on this block. Orbit around and place the cursor on any of the faces. Pull and push them to create different block shapes.

You'll use the Push/Pull Tool frequently to draw boards to the appropriate length, width, and depth. The Push/Pull Tool is also extremely versatile for shaping wood, such as making mortises, tenons, rabbets, grooves, and dovetails.

To further shape the block, draw a line across the top face and another across the front face, as shown in Figure 13.

When you connect lines or cross lines, the existing lines are divided into pieces. The top right edge of the block was one line originally. But by drawing of the new line across the top face, the top right edge now consists of two segments. Use the Select Tool to click on each segment. Note that only the segment you select is highlighted. Likewise, drawing a line across a face divides it into separate parts. Use the Select Tool again to click on faces and see how the single face is now divided.

Select the Push/Pull Tool and pull out part of the top and front faces of the block, as shown in Figure 14. Then draw two lines on the small front face of the block, as shown in Figure 15. Select the Push/Pull Tool and click on the small rectangle you just drew on the front corner of the block. Release the mouse button; do not hold it down. Push your mouse along the green direction—toward the background—and toward the back of the block. You have just begun to create a rabbet.

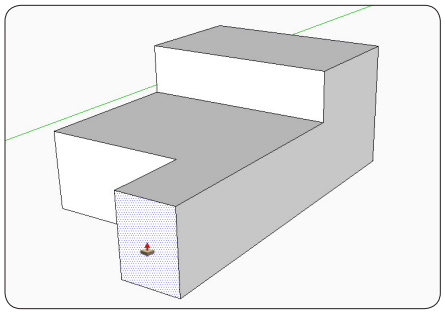


Figure 14. *Once you have divided a face, you can use the Push/Pull Tool to extend specific parts. It's a technique used to create tenons, for example.*

You can stop the rabbet at any point along the edge by clicking the mouse. Or, to run the rabbet all the way along that side of the block, click the mouse on the back edge of the block (Figure 16).

The Select Tool

When you choose the Select Tool, the cursor becomes a short arrow. The tool's name describes its function: Use it to select things in the model. It can select one thing or many, depending on how you use the tool.

Figure 17 shows one edge selected. Put the cursor over the line and click the left mouse button. The line changes from black to blue. If you then hold down the Shift key and click in an adjacent face, you will have both the line and the face selected. The pattern of blue dots on the face tells you it has been selected. Note, too, that when you hold down the Shift key, a plus (+) sign appears next to the arrow; this indicates that you can select more than one item.

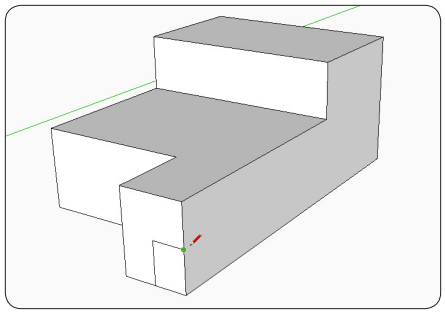


Figure 15. *Adding lines to a face to begin shaping a rabbet along one edge of the block.*

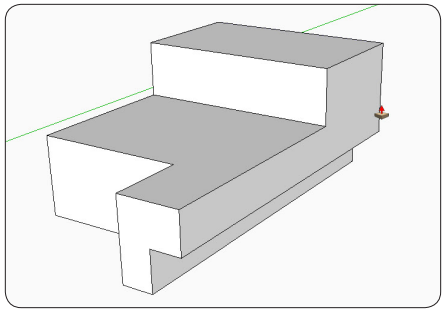


Figure 16. *Using the Push/Pull Tool to create a rabbet.*

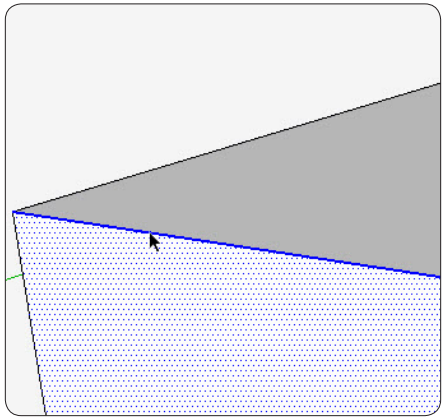


Figure 17. *Using the Select Tool to highlight an edge.*

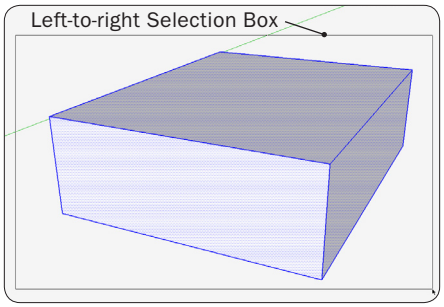


Figure 18. *Moving left to right with the Select Tool generates a solid selection box. That selects any element contained within the box, as shown by the blue lines.*

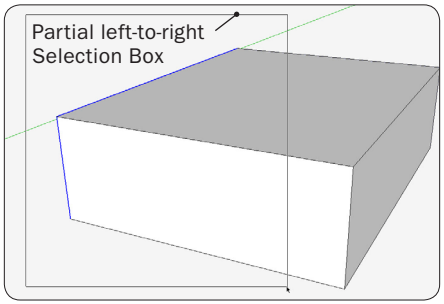


Figure 19. *A partial left-to-right selection leaves some elements untouched.*

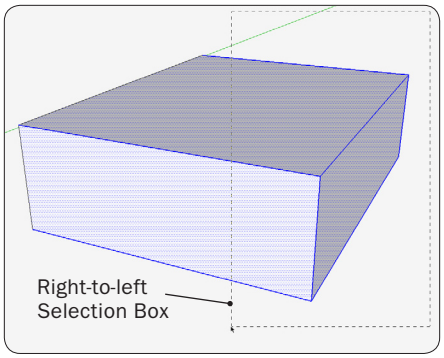


Figure 20. *Moving right to left with the Select Tool generates a dotted Selection Box. In this case, anything the box touches will be selected.*

There are several reasons to select things in a model: to move, scale, delete, copy, or group things, or to make a component. So, with the top and edge selected as in Figure 17, if I pressed the Delete key on the keyboard, I would remove only those two items.

You can use this tool several ways to quickly select all or part of a model.

Left-to-right drag Use the Select Tool to click and drag a box around the modeled block, moving the mouse from the upper left to the lower right of the screen. This creates a solid selection box, as shown in Figure 18. All things entirely within the box are selected and highlighted. If you drag the box only part-way across the modeled block, as shown in Figure 19, only fully enclosed items are selected. In this case the box fully encloses only two edges and one side face, so they are selected and highlighted.

Right-to-left drag Clicking and dragging the Select Tool from right to left produces a different result. The box is shown with a dashed line, and anything the box touches will be selected. So, as shown in Figure 20, the front and top face are highlighted but not the left vertical and horizontal top edge.

Double and triple clicking You can also use multiple mouse clicks to quickly select all or part of an object. Move the Select Tool cursor over the front face of the block. Double-click the left mouse button. This selects and highlights the face and its four bounding edges, as shown in Figure 21. Triple-click to select the entire block. And if, after you have selected everything, you click a fourth time, that will deselect everything but the face the cursor is over.

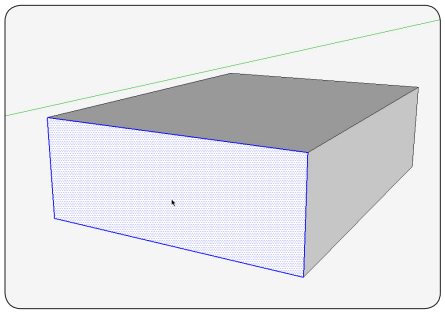


Figure 21. *You can double-click with the Select Tool to select all edges and faces in an object.*

The Rectangle Tool

After picking the Rectangle Tool, click and release the left mouse button to set the location of the rectangle's starting corner. Move the mouse to size the rectangle; click the mouse again to finish the shape.

When the angle of view is looking down on the model, as shown in Figure 22, the rectangle will draw on the red–green plane. To draw a rectangle standing up vertically, use the Orbit Tool to make the angle of view more straight on.

A plane or face has two sides. SketchUp uses blue to represent the back side of a face; white, to represent the front. These faces are created automatically, and SketchUp guesses as to front and back. Sometimes it's wrong, and you will see a blue face that should be white. Figure 23 shows a rectangle with the wrong face forward. To reverse the faces, right-click on the face and select Reverse Faces from the pop-up menu. The face will turn white.

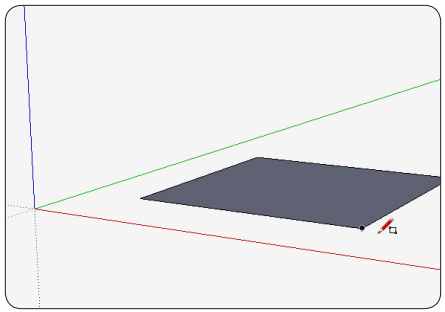


Figure 22. *Drawing with the Rectangle Tool.*

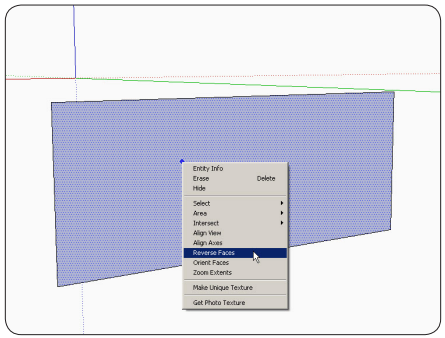


Figure 23. *When you right-click an object using the Select Tool, a pop-up menu appears to give you a list of editing options. Here, the faces of the object are being reversed.*

The Circle Tool

Click on the Circle Tool and hover the mouse over the top surface of the block. A small blue circle will appear. The blue color signals that the circle will be created on the blue axis; its face will be in the red–green plane (the same plane as the top surface of the block). A small

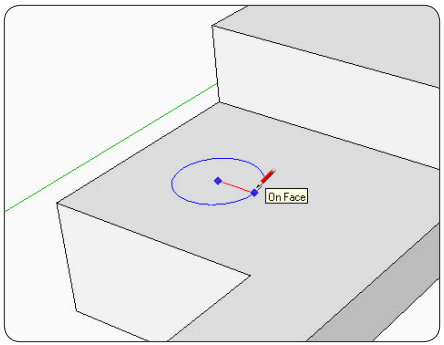


Figure 24. *Placing a circle on the blue axis (the face is on the red–green axis).*

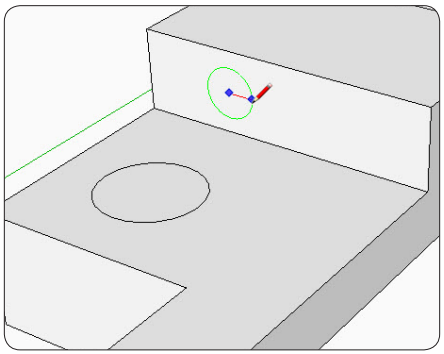


Figure 25. *Placing a circle on the green axis (the face is on the red–blue axis).*

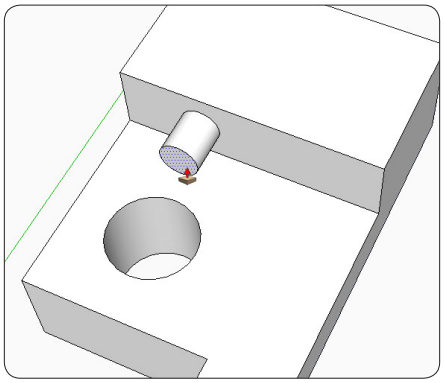


Figure 26. *Using the Push/Pull Tool with the circles to create a hole and a dowel.*

label (On Face) near the circle tells you that you are drawing the circle on the face of the block.

Click the left mouse button to fix the location of the circle's center point. Release the button and drag the mouse to expand the circle's radius. Click again to fix the circle's size on the face, as shown in Figure 24.

Hover the mouse over a vertical face on the block, as shown in Figure 25. This time, the circle appears in green, meaning it will be created on the green axis because its face is on the red–blue plane. As you did before, click the mouse to position the center point of the circle, move the mouse to the desired radius, and click again.

You can use the Push/Pull Tool to modify circles, turning them into dowels or holes, as shown in Figure 26. To do that, select the Push/Pull Tool and move it over one of the circles you drew. A pattern of blue dots inside the circle tells you that you have selected it. Click the mouse, release the button, then move the mouse to either push the face to create a hole, or pull it to make a pin or a dowel. Click again to stop the action.

The Arc Tool

To see how the Arc Tool works, place an arc on the top edge of the block, as shown in Figure 27. Select the tool, click once on one of the edges, then click the mouse on the other edge. Now move the mouse to see how the arc changes size and shape. As the figure shows, the arc's color changes to magenta when it is tangent to an edge. Also, there is an inference that tells you when you are at the same distance from the endpoints—that is, at a 45 degree angle. Then you get tangency to both edges. Click again to fix the position and shape of the arc. In this case, the tangency determines the bulge of the arc.

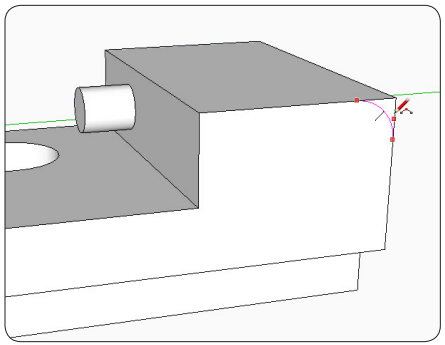


Figure 27. *Using the Arc Tool to place an arc. The magenta color signals that the arc is tangent to a face on the red axis.*

However, there are many instances in which you want to specify the height of an arc. You can do that by using the Measurements Box in the lower right-hand corner of the screen. (The Measurements Box is more fully explained in Chapter 5). As you use the mouse to change the bulge of the arc, the numbers in the Measurements Box also change. You can type a number and hit the Enter key to fix the shape of the arc.

Choose the Push/Pull Tool and click on the small triangle above the arc shape you just drew; the blue dots will signal that you've selected that area. Push along the green axis, toward the background, then click on the back edge of the block (Figure 28). This is one way to round over edges and create moldings.

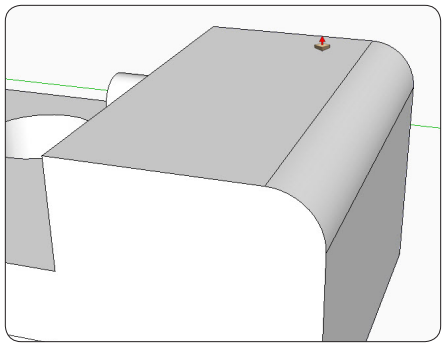


Figure 28. *Using the Push/Pull Tool to remove waste next to the arc, creating a roundover edge.*

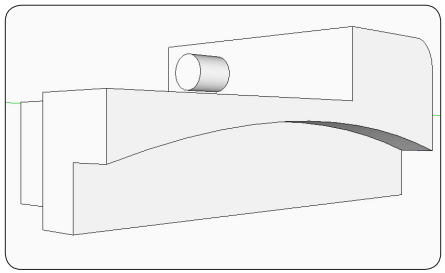


Figure 29. *Placing an arc with the Arc Tool and then using the Push/Pull Tool to create a cove.*

Click the Arc Tool on one end of the edge of the rabbet, then click on the other end. Push the mouse upward, along the blue axis, to create a cove shape. Click again. Now use the Push/Pull Tool to create the cove shape shown in Figure 29.

The Tape Measure Tool

SketchUp has a rich set of layout and construction lines (temporary dotted lines) called guides. I find guides essential for furniture design. You use them to lay out and position cuts, holes, grooves, rabbets, tongues, and any other joinery shape. Most of the

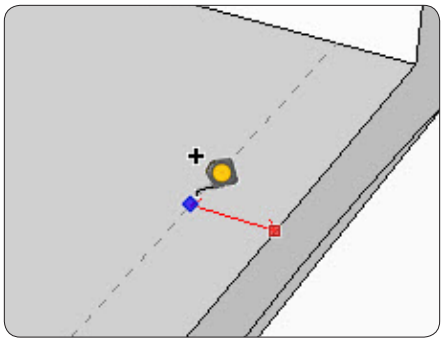


Figure 30. *Using the Tape Measure Tool to place a guide parallel to an edge.*

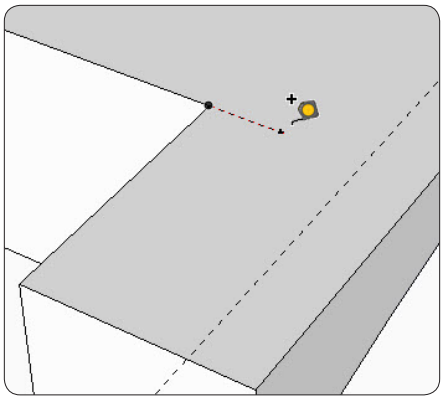


Figure 31. *Using the Tape Measure Tool to set a guide point near a corner.*

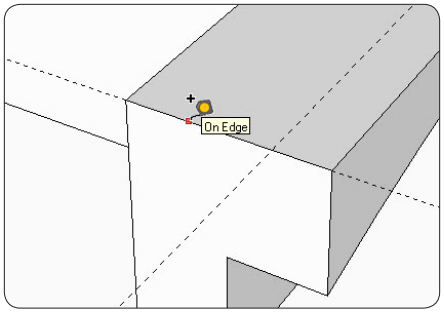


Figure 32. *Using the Tape Measure Tool to place a Linear Guide, one that coincides with an edge.*

time, you use the Tape Measure Tool to create the guides you need (when you need a guide placed at an angle, you use the Protractor Tool, which is covered on page 41). The type of guide the Tape Measure Tool creates depends on where you first click the mouse. Setting guides can be frustrating at first, but with practice, you can increase your efficiency and speed.

I will use our working block to show the various ways to use the Tape Measure Tool.

Parallel Guide Line As shown in Figure 30, place the very tip of the Tape Measure Tool icon on an edge in a component, click, and move the mouse to the left, along the red axis. A dotted line, parallel to the edge line, follows the mouse movement. Click again to set the position of the line. When you want a parallel guide a specific distance from an edge, type the desired value. This value will appear in the Measurements Box.

Occasionally, the Tape Measure will create a Guide Point (a small, heavy cross) instead of a Parallel Guide Line. Unless you started the Tape Measure Tool at a corner, this can happen when the Tape Measure Tool senses an inference to some other corner or feature. To correct the problem, shift the location of your starting point to be free from the automatic inference.

Guide Point As shown in Figure 31, position the tip of the Tape Measure Tool on a corner, click and release the mouse, move the mouse to the right, and click again to set the guide point.

I use guide points occasionally to find a circle's center or a point's distance from a corner. guide points are difficult to delete, so I don't use them as often as guide lines. However, you can delete all guide lines and guide points in the model with a couple of mouse clicks. Go to Edit in the Menu Bar and choose Delete Guides from the drop-down menu

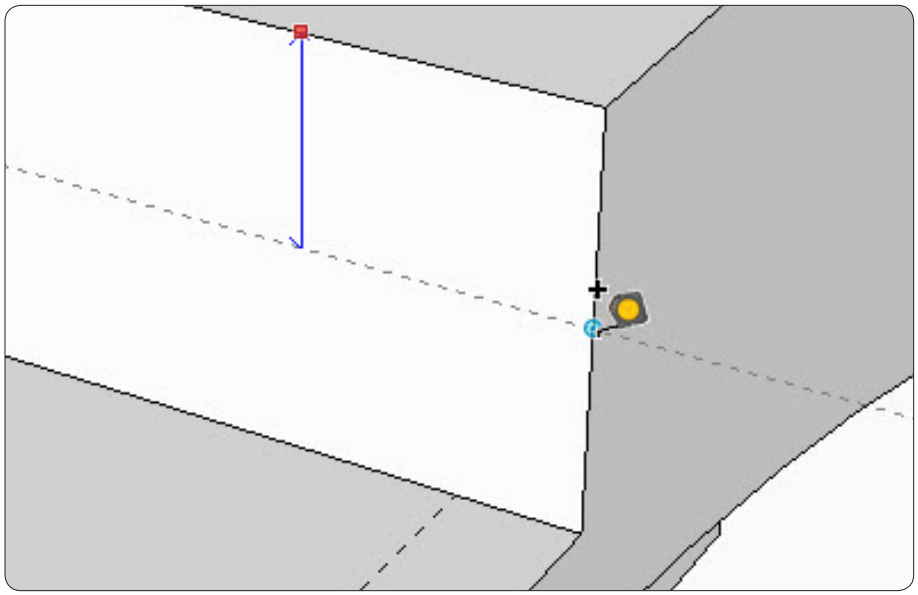


Figure 33. *Using the Tape Measure Tool to locate the centerline of a face. The cyan-colored dot tells you that you have moved the tool to the proper place.*

Linear Guide Line A Linear Guide aligns with a particular edge, as shown in Figure 32. To set this type of guide, double-click the Tape Measure Tool on the desired edge. I use Linear Guides quite often when I need to line up components or find the intersection of two angled lines.

I often need to locate the centerline of a face, which I can easily do with the Tape Measure Tool. Click on one edge, move the mouse over to a perpendicular edge, and slide it along that line. As shown in Figure 33, you will see a cyan-colored dot when you have moved to the midpoint. Click the mouse again. Now you have a guide running down the center of the face.

You can also use the Tape Measure Tool as a tape measure. When you use the tool to draw guide lines, a plus sign appears. Click the Ctrl key (Option on a Mac) to remove the plus sign. Now you can click to start a measurement, move the mouse to the endpoint, and click the mouse again. You can read the dimension in the Measurements Box.

Learn to Draw Precisely

Measurements dominate woodworking. The rule and tape measure are always within reach because you continually check length, width, thickness, height, depth, distance, and so on. Accuracy and precision are critical for the drawings and plans you use as well. If you don't pay enough attention to detail, especially to dimensions and measurements, your shop experience can be a frustrating stint of reworking.

One of SketchUp's strengths is its ability to produce high-quality, accurately dimensioned drawings that you can print. Building an object in SketchUp requires the same kind of accurate fitting that real joinery does in the shop. When parts don't fit in SketchUp, you can see that immediately and can easily make precise corrections. When you place a dimension, you can count on its accuracy.

One of the most complex assemblies I've ever attempted is the tail vise shown in Figure 1. It's part of the workbench described in "A Challenging Project" at the right. With this kind of intricate assembly, it's essential to have a high-quality design with accurate dimensions.

You'll learn how to produce a precise, accurately dimensioned drawing of your own by drawing the end piece of the workbench in SketchUp (The tail vise parts fit up with this end piece.)

Begin by printing Figure 2, a full-page dimensioned drawing of the workbench end. Keep it next to your computer so you can refer to it.

As you create your own drawing, you will use the Measurements Box, located in the lower right-hand corner of the SketchUp screen (Figure 3). As you use different drawing tools, the values shown in the box change to tell you exact line length, circle radius, arc bulge, rectangle size, distance moved, angle rotated, and protractor angle. The label to the left of the box changes to tell you what value will be shown.

SketchUp controls the Measurements Box and decides which parameters are applicable for the specific tool or action involved. You cannot click to enter the box or force it to change parameters, say. However, with most drawing tools, you can select the tool, begin using it, and type a value that will appear in the Measurements Box. What you type—2½ for a line length, for example—controls what appears in the drawing. You'll understand how this works as you go through the process of drawing the workbench end.

Drawing this object will introduce you to these essential skills:

- How to place guide lines to locate things.
- How to use the Measurements Box, typing length or distance values.
- How to master the Push/Pull and Line Tools.
- How to keep your drawing on-axis.

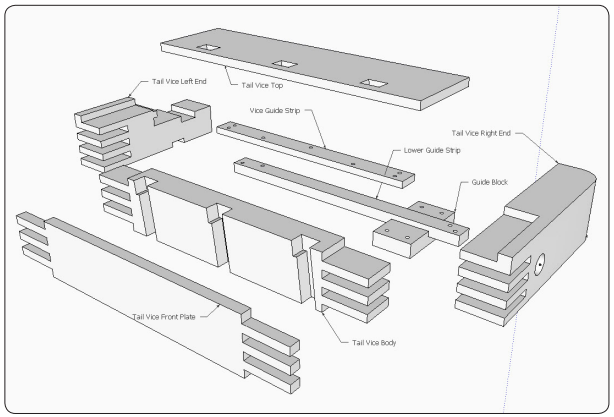


Figure 1. *The parts of the tail vise from the Tage Frid workbench. Re-creating the bench proved challenging.*

A Challenging Project

In the summer of 2007, my local woodworking group (Diablo Woodworkers of Pleasant Hill, California) began building nine Tage Frid cabinetmaker's workbenches like the one shown in Figure A. About 600 board feet of rough maple, German-made vise screws and bench dogs, and a comprehensive package of my SketchUp drawings made us eager to get started.

The SketchUp package consisted of 75 pages of details, X-Ray views, close-ups, orthographic views, exploded views, and full-size templates. I e-mailed the document to participants several weeks before the first day in the shop. The 18 participants printed their own package for use during construction.

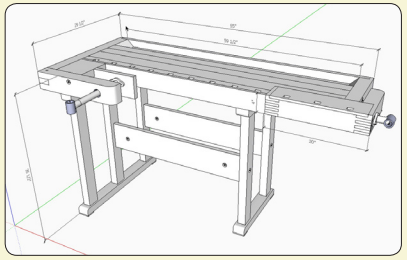


Figure A. *The Tage Frid workbench.*

The full-size templates were invaluable, ensuring that each piece of maple could be marked up precisely.

Although the actual building took longer than we thought, at least we did not have to deal with confusing or erroneous drawings. SketchUp provided a high-quality document package without the faults commonly found in complex woodworking plans.

Making the benches was a very challenging but satisfying experience for the group. It increased our confidence in tackling other difficult furniture projects. SketchUp has been a big part of our success.

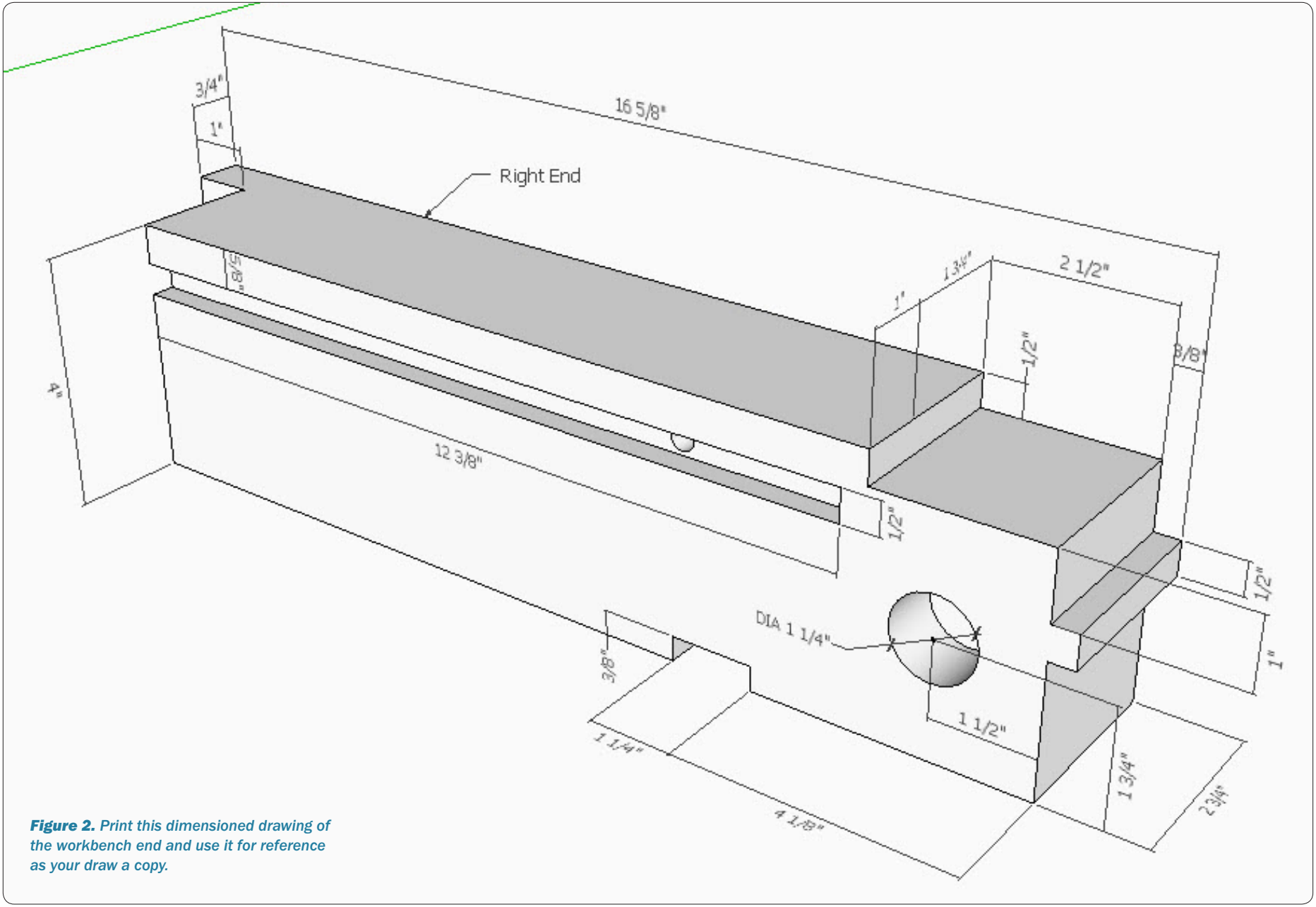


Figure 2. *Print this dimensioned drawing of the workbench end and use it for reference as your draw a copy.*

Precise drawing, step by step

Step 1 Select the Line Tool; note that the Measurements Box is now labeled "Length." Somewhere in the middle of the modeling window, click the mouse to begin drawing a line. Move the mouse left to right to draw the line on the red axis. Be sure the line is red, showing that it is on-axis (Figure 4). Note how the numbers in the Measurements Box change as you lengthen the line. To finish the line, type 16⅝ and press the Enter key. This will produce a line exactly 16⅝ in. long, which is the overall length of the workbench end. (You can type customary fractions or decimal values; if you use fractions, type a space and not a hyphen between a whole number and the fraction.)

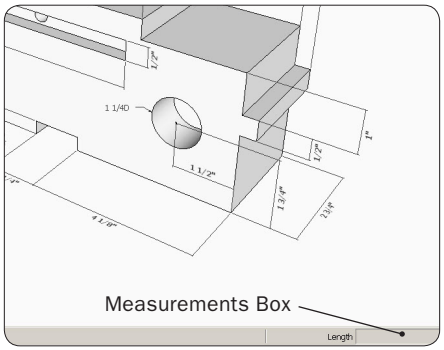


Figure 3. *The Measurements Box is the key to precise drawing.*

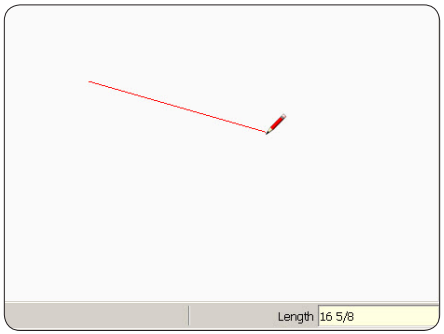


Figure 4. *To draw a line to an exact length, type the length. The number appears in the Measurements Box.*

Step 2 Continue a line upward, on the blue axis. Type 4 and press the Enter key. This creates the full height of the workbench end (Figure 5).

Step 3 Finish the front face of the workbench end with the Line Tool. Be sure your lines remain on the red and blue axes. Use the inferences that SketchUp shows to set the line lengths. That is, stop the line where the inference indicates. You should have a rectangle measuring 16⅝ in. wide and 4 in. high, on the red–blue axis.

Select the Push/Pull Tool; note that the Measurements Box is now labeled "Distance." Click on the front face of the rectangle, but don't hold down the mouse button. Move the mouse so that the Push/Pull Tool moves toward the background. Notice how the values in the Measurements Box change. Type 2¾ and press the Enter key. This will produce a block representing the workbench end (Figure 6).

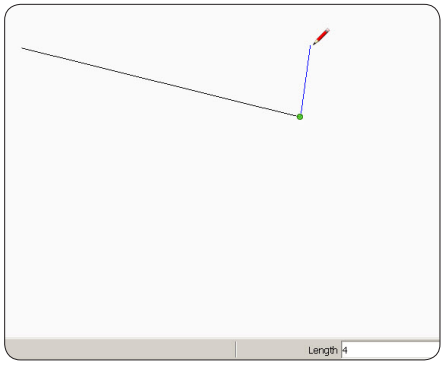


Figure 5. *Drawing a 4-in.-long line on the blue axis.*

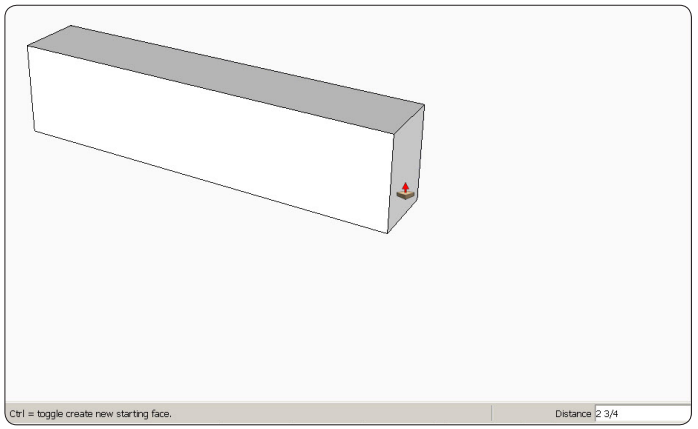


Figure 6. *Use the Push/Pull Tool to create thickness. Type the amount of thickness; the figure is displayed in the Measurements Box.*

Use the Tape Measure Tool to check the length, height, and depth. Select the tool, place its tip on a corner of the block, and click the mouse. Move to the opposite corner; green dots will appear at the corners, and a box below the tool's icon will show the measurement for that edge. To use the tool as a tape measure, tap the Ctrl key (Option on a Mac); then you can click at both ends of the measurement.

Step 4 Now you will create the large rabbet on the top face and the tongue on the end of the block. Begin by adding guide lines to your model.

Select the Tape Measure Tool, click on the top right edge, and move the mouse right to left to start a Parallel Guide Line on the top face. Type ⅜ and press the Enter key to create the first top guide line. It marks the length of the tongue. Start another guide line. Repeat those actions, beginning at the guide you just placed. Type 2½, and press the Enter key to locate the second guide line. It defines the top of the rabbet (Figure 7).

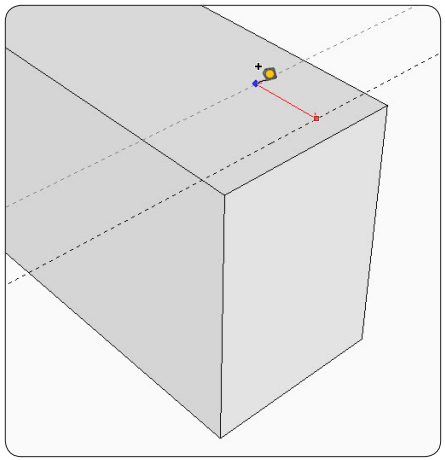


Figure 7. *Placing Parallel Guide Lines to fix the location of a tongue and a rabbet.*

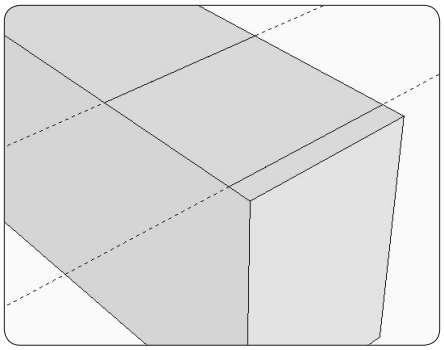


Figure 8. *Lines drawn over the guide lines.*

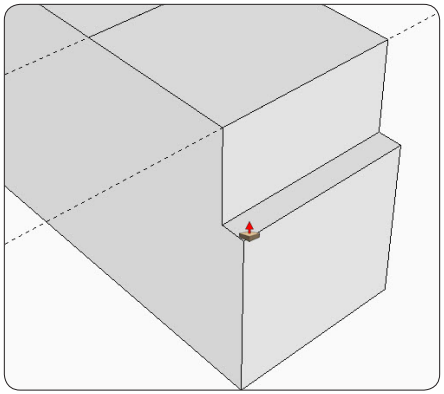


Figure 9. *Using the Push/Pull tool to create the upper face of the tongue.*

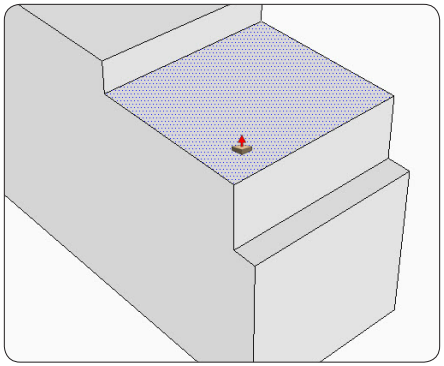


Figure 10. *Using the Push/Pull Tool to shape the rabbet.*

Step 5 Select the Line Tool and use it to create two lines on the top face. Draw over the two guide lines (Figure 8).

Step 6 Select the Push/Pull Tool. Click on the narrow rectangle at the right end of the top face. Use the tool to push that part of the face downward, along the blue axis. Type 1½ and press the Enter key. This creates the upper shoulder of the ⅜-in.-deep tongue, as shown in Figure 9.

Use the Eraser Tool to delete the two guide lines, which are no longer needed. You can also remove the guide lines by choosing Edit from the Menu Bar, then clicking on Delete Guides in the drop-down menu.

Step 7 Select the Push/Pull Tool. Click on the area at the right of the top face. Use the tool to push that part down by typing ½ and pressing the Enter key (Figure 10).

Step 8 Use the Tape Measure Tool to create another Parallel Guide Line ½ in. down from the upper shoulder of the tongue, as shown in Figure 11.

Step 9 Use the Line Tool to draw a line over that guide line. Then select the Push/Pull Tool and use it to select the lower portion of the right face. Use the tool to push that part of the face along the red axis, from right to left. To end the movement, use the existing upper surface as a reference. That is, hover the Push/Pull Tool over the existing upper surface, then click the mouse to end the push/pull movement (Figure 12). For this type of modeling, it is easier to use reference faces than to type in a value. This completes the tongue. Delete the guide line.

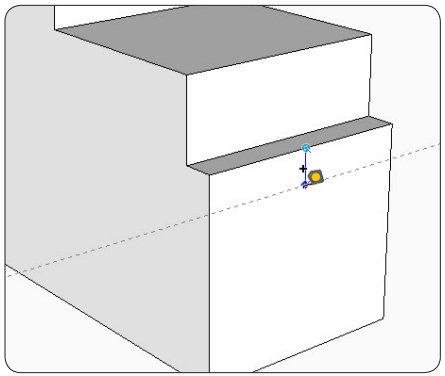


Figure 11. *A new Parallel Guide Line marks the width of the tongue.*

Step 10 This block has a 1¼-in.-diameter hole for the shaft of the tail vise. To draw the hole, begin by using the Tape Measure Tool to place two Parallel Guide Lines to locate the center. Place one guide 1¾ in. up from the bottom edge of the block. Place the other 1½ in. from the right edge of the block. Type those values (1¾ and 1½) the Measurements Box, as before (Figure 13).

Step 11 Select the Circle Tool. Fix the center of the circle by clicking at the intersection of the two guide lines. (A label will appear to tell you that you're on the intersection.) Release the mouse button and move the mouse to lengthen the radius. Note that the Measurements Box is now labeled "Radius." Type ⅝ (half of 1¼ in., or the radius of the hole), and press the Enter key (Figure 14). Delete the guide lines.

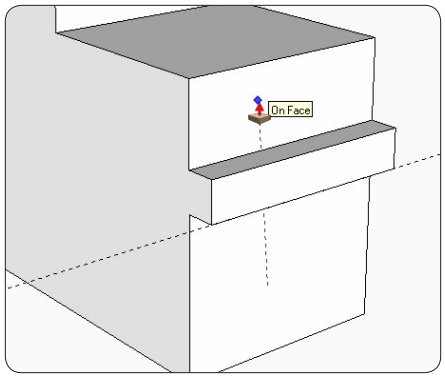


Figure 12. *Using the Push/Pull Tool to finish the tongue. Here, you hover the tool over the face above the tongue to quickly set the proper depth. That's actually faster than typing a value.*

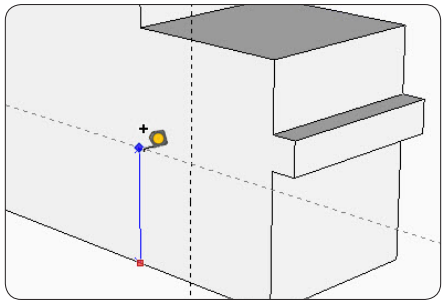


Figure 13. *Placing intersecting Parallel Guide Lines to locate the center of a hole.*

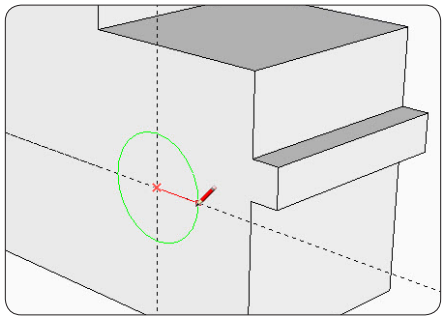


Figure 14. *The Circle Tool placed over the intersection, ready to begin drawing the hole.*

Step 12 Select the Push/Pull Tool. Click on the face of the circle, release the mouse button, and move the mouse so that the face of the circle moves to the background. Click the Push/Pull Tool on the back edge of the block. This will end the movement on the back face and create a hole that is open on both sides, as shown in Figure 15. Use the Orbit Tool to change your view so you can see through the hole.

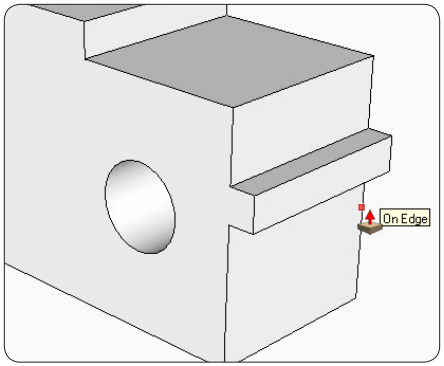


Figure 15. *Using the Push/Pull Tool to create the hole. The "On Edge" label next to the tool tells you when you've pushed far enough.*

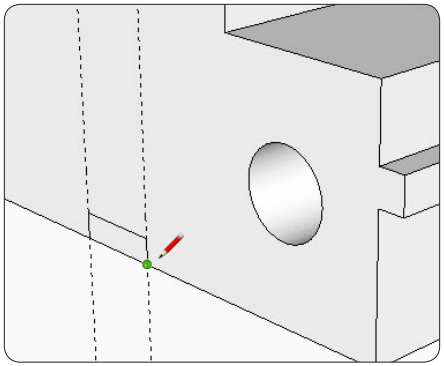


Figure 17. *Drawing along the guides to create the profile of the dado.*

Step 13 A ⅜-in.-deep dado runs across the bottom face of the piece, providing a channel for a wooden guide in the vise assembly. To create the dado, begin by placing two Parallel Guide Lines on the front face to define the width of the dado. Use the Tape Measure Tool to place the first guide line 4⅛ in. from the right edge of the piece. Place the second guide line 1¼ in. to the left of the first. The guide lines should look like the ones in Figure 16.

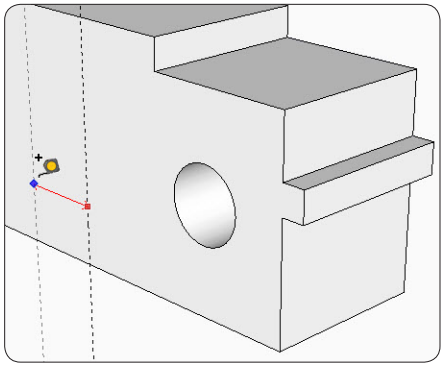


Figure 16. *Two Parallel Guide Lines mark the edges of a dado on the bottom of the piece.*

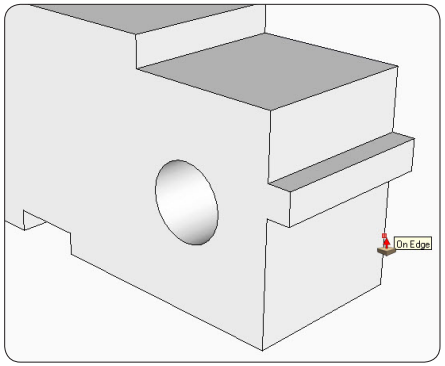


Figure 18. *Using the Push/Pull Tool to shape the dado.*

Step 14 Select the Line Tool and use it to draw the shape of the dado on the front face. You will draw over the guide lines. The first line can be vertical, beginning at the bottom edge and moving up ⅜ in. Start the line upward on the blue axis, type ⅜, and press the Enter key. Continue a line from right to left along the red axis over to the other guide line, then down to the bottom edge (Figure 17). Delete the guide lines.

Step 15 Select the Push/Pull Tool. Click on the face of the dado, release the mouse button, and move the mouse to push the dado toward the background. Click the Push/Pull Tool on the back edge of the end piece. This ends the push/pull movement and creates a dado, as shown in Figure 18. Use the Orbit Tool to change your view so you can see through the dado.

Step 16 The left end of the piece has a cutout. Use the Orbit Tool to move close to the left end of the piece. Begin creating the cutout by placing a Parallel Guide Line ¾ in. from the back edge, as shown in Figure 19.

Step 17 Select the Line Tool. Use it to draw a vertical line over the guide line. Select the Push/Pull Tool. Use it to push the cutout to a depth of 1 in., as shown in Figure 20. Delete the guide line.

Step 18 The remaining detail is a ⅜-in.-deep groove in the front face of the piece. Begin to draw it by using the Tape Measure Tool to place a Parallel Guide Line ⅝ in. down from the top of the left end of the piece, as shown in Figure 21.

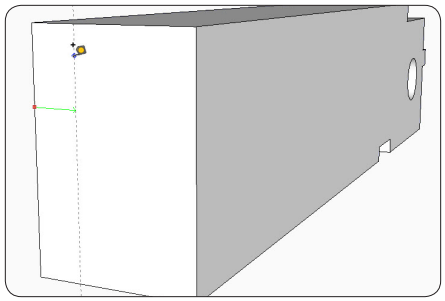


Figure 19. *Placing a Parallel Guide Line for a cutout on the end of the piece.*

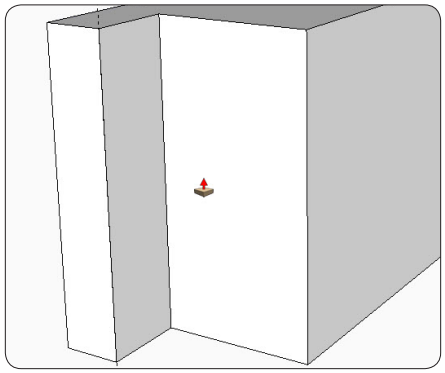


Figure 20. *After drawing a line over the guide-line, use the Push/Pull Tool to create the cutout.*

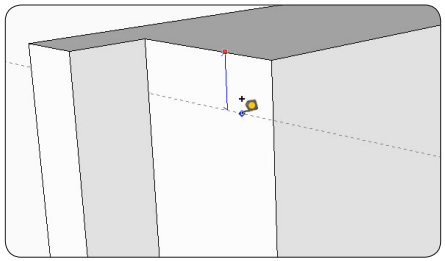


Figure 21. *Placing a Parallel Guide Line to locate the top edge of a stopped groove on the face of the piece.*

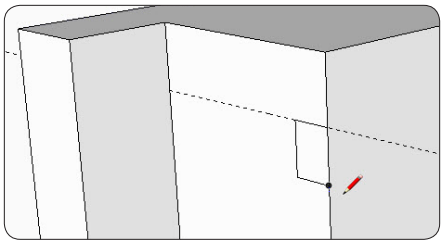


Figure 22. *Using the Line Tool to draw the shape of the groove.*

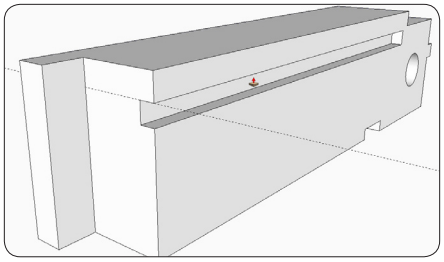


Figure 23. *Use the Push/Pull Tool to make the cutout for the groove. Type a value to give the groove a precise length.*

Step 19 Select the Line Tool. Use it to draw the boundary of the groove, which is ⅜ in. deep and ½ in. wide. Zoom in close to the model, if necessary, to better see what you are doing. As before, move the Line Tool and type the desired lengths. When you've finished, the end of the piece should look like the one shown in Figure 22.

Step 20 Select the Push/Pull Tool. Use it to click on the shape of the groove, then push left to right along the red axis. Type 12⅜ and press the Enter key. This creates a stopped groove exactly the right length, as shown in Figure 23. Delete the guide line.

Congratulations! You have just created a detailed, complex woodworking part.

Why Can't I Get a Face?

I suspect this has already happened to you: You've drawn a nice shape, but the face will not appear. Don't worry, this will continue to happen, especially when you begin drawing complex shapes. I'm in my fifth year with SketchUp, and it continues to happen with every new piece I design. Often, it is just unexplainable, and you can't figure out what caused the problem. You've checked that all lines are indeed on-axis, so the shape seems to be coplanar. Even so, the face will just not appear.

The quick fix is to draw a line over one of the edges, endpoint to endpoint (see Figure A). This is called "healing" and will probably restore the face successfully. However, healing doesn't work every time. No matter how many times you draw over the edges, nothing happens. What are some of the other remedies you can try?

First, look at the model from several angles. SketchUp can fool you. For example, in the front view shown in Figure B, the rectangle looks perfect. However, when you use the Orbit Tool, the problem becomes quite apparent. In this case, one vertical edge is off at an angle, making a figure that isn't coplanar. Use your mouse with the Orbit, Zoom, and Pan Tools. Look at your object from all angles to see if a line or an edge is off-axis.

The next step is to look for extra line segments that are in the way of the face. In Figure C, I've shown two extraneous line segments. No matter how many times you try to heal this shape to create a face, it won't work. These extra line segments are blocking the automatic creation of a face. Sometimes, the extra lines are very easy to see and erase. However, often they are hidden next to a line you want to keep. It takes close visual inspection to detect and delete such lines.

If those two steps don't work, it is usually best to delete the shape and start over. Occasionally, you will find that a component will have one good face, but you can't get the back face to close, as shown in Figure D. Use the Eraser Tool to delete the thickness of the component, leaving only the front face. Then use the Push/Pull Tool to re-create the component.

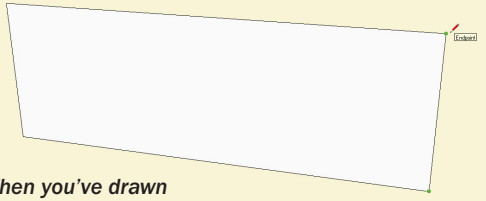


Figure A. *When you've drawn a shape but a face doesn't appear, try drawing over one of the lines. This "healing"often fixes the problem.*

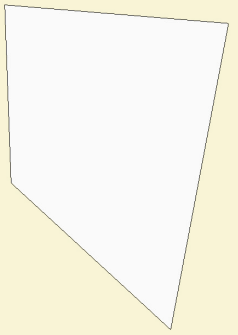


Figure B. *From the front, this rectangle looks right. But when you use the Orbit Tool to look at the side, you can see that one side is off-axis.*

Figure C. *Sometimes, extraneous lines interfere with a shape, so a face won't appear.*

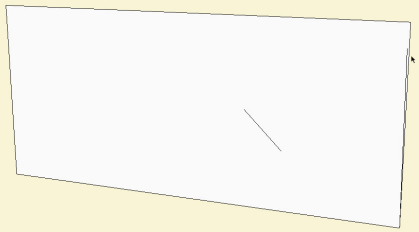
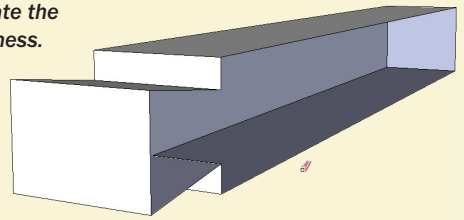


Figure D. *When you get a shape with one good face and one bad, it's best to delete everything but the good face and use the Push/Pull Tool to re-create the shape's thickness.*



How to Make, Move, Copy, Edit, and Connect Components

One of SketchUp's most important features is the Make Component function. Without it, you'd be better off sketching by hand.

Woodworkers create, move, connect, copy, and modify furniture or cabinet parts. Components are the SketchUp equivalent—legs, stretchers, tops, drawer fronts, knobs, rails, stiles, panels, slats, arms, seats, and so on. When you add a mortise to a leg in SketchUp, you are editing a component called "leg," which is an integrated object, not a bunch of individual edges, lines, and graphical entities. You can touch the leg (using the Select Tool), move, copy, and change it as if it were a real piece of wood.

Components are essential for success in SketchUp. Without them, all you have are a bunch of lines and faces that interact and interfere with one another. There is no other way to work with the model; you must create pieces (components) that represent each part of the woodwork assembly.

Without components, you would not be able to create an exploded view, like the tea table shown in Figure 1. The table consists of 8 uniquely defined components and a total of 19 distinct components or pieces. For example, there is one leg component definition and four instances (or copies) of it.

Not only do components make it possible to create the separate parts of a piece of furniture, but they also add considerable speed, efficiency, and accuracy to the modeling. When you make a change to one copy of a component, the same change instantly appears in all copies of that component. For example, when you add mortises to a leg to hold tenons on a table apron, you need to draw the mortises only once. All the other legs are changed instantly and identically. I wish that happened in the shop.

In a single SketchUp design file, I generally have multiple copies of the leg components within Orthographic, Exploded, and Detail views. Modifying a leg in any one of those views automatically modifies them all. That lets me complete a design file and get to the shop quickly.

SketchUp also lets you create *groups*, which are similar to components but not nearly as powerful or versatile. You can group lines, edges, faces, and other graphical entities into one integrated item. You can copy and move these groups within the design file. Groups differ from components in one important way: Copies of groups do not automatically update. I think that's reason enough to avoid using groups in woodworking models. Use components instead.

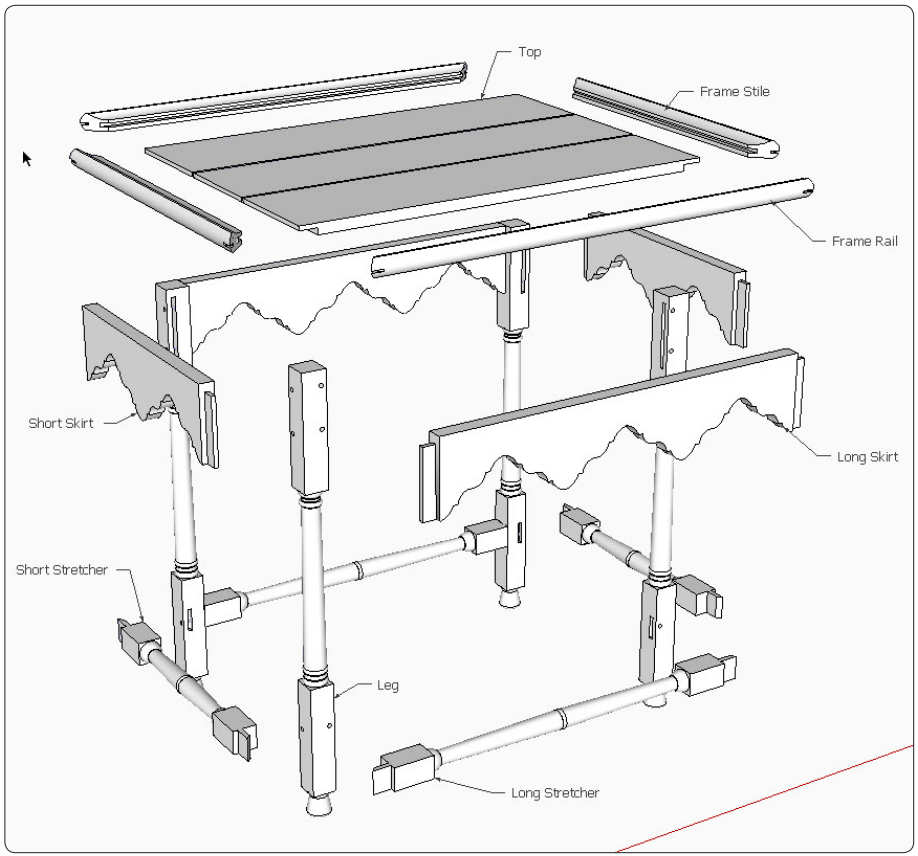


Figure 1. *The elements in this square tea table are components, the SketchUp equivalent of pieces of wood that have been milled, shaped, and turned.*

It's best to create components right up front when you begin a model, even before the "piece of wood" is entirely shaped with moldings, joints, or other embellishments. This will make your modeling more efficient and accurate.

How to Make a Component

In this example, you'll make a simple leg component. The steps are the same for any component.

Draw a square leg, as shown in Figure 2. The one shown is 26 11/16-in. long and 1 7/16-in. square, the overall size of the tea table leg; you can make yours any size you want. To make this a leg component, draw a left-to-right Selection Box around all the edges and faces that represent the leg. The selected items will change to blue.

As shown in Figure 3, right-click on the selection and choose Make Component from the pop-up menu. This will open

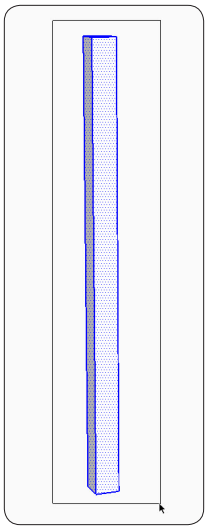


Figure 2. *To begin making a component, draw the item you want, then draw a left-to-right Selection Box around it.*

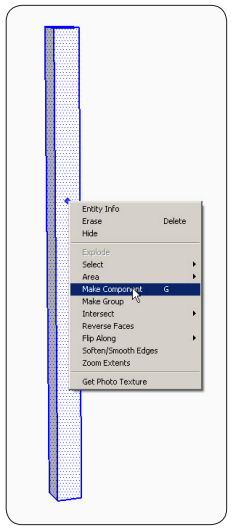


Figure 3. *Right-click on the selection to open a pop-up window.*

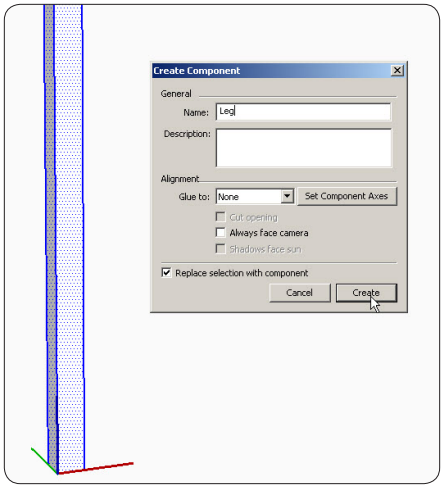


Figure 4. *To finish making a component, give it a name in the new window, then click the Create button.*

another box, as shown in Figure 4, asking you to name the component. Enter a name and click on the button labeled Create.

After creating the component, use the mouse to click on it once. That selects the entire object, not just a single line, edge, or face. What you drew now represents a piece of wood that can be modified, moved, copied, and connected to other components.

How to Move a Component

You move components around the model with the Move/Copy Tool (Figure 5). When you use this tool, the cursor changes to a four-way arrow shape. Here's how this operation works.

Choose the Move/Copy Tool and move the cursor over the leg component. This automatically selects the component; note how it changes to bright blue. Figure 6 shows the screen when I hovered over the upper front corner of the leg. SketchUp lets you know when you are on the corner by displaying a label next to the cursor that says "Endpoint in Component." SketchUp also displays a magenta dot at the endpoint. I find that it's best to move a component by latching on to one of its corners, especially when you need to connect two components corner to corner.

Click the mouse button (but don't hold the button down), and move the mouse. See how the leg also moves in the direction of the mouse. You can move the component on any of the axes. SketchUp will tell you when you are on-axis by displaying a colored dotted line that trails the component as you move it

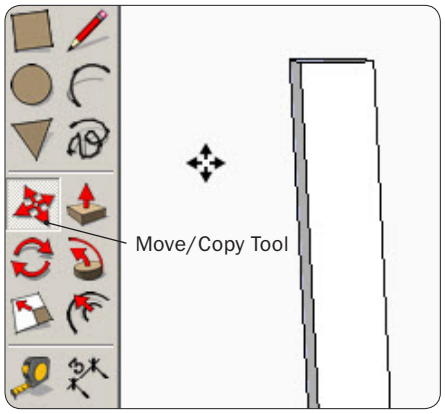


Figure 5. *Choosing the Move/Copy Tool changes the cursor to a four-way arrow.*

and by displaying a label, such as "On Red Axis." When you are satisfied with the component's new location, click the mouse button to release the component and stop its movement.

You can also use the Move/Copy Tool to rotate a component on any one of the three axes. Using the leg component as an example, zoom in close to the top of the leg. Choose the Move/Copy Tool and hover over the top face of the component. Small red plus signs appear on the top face, and a protractor icon appears in the center when you hover over one of the plus signs. The mouse icon changes to a pair of chasing arrows, indicating that the component will be rotated (Figure 7).

Click and move the mouse. The leg will rotate around its center on the blue axis. For more precise rotation, type an angle, which will show up in the Measurements Box, and press Enter to end the rotation. Or move the mouse until you see the desired angle in the

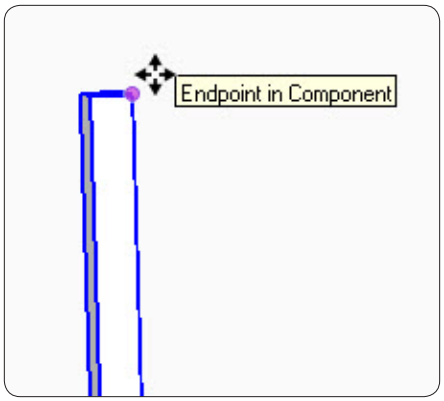


Figure 6. *When you hover the Move/Copy Tool over a component, SketchUp shows you with a magenta dot and a label when you're on an endpoint.*

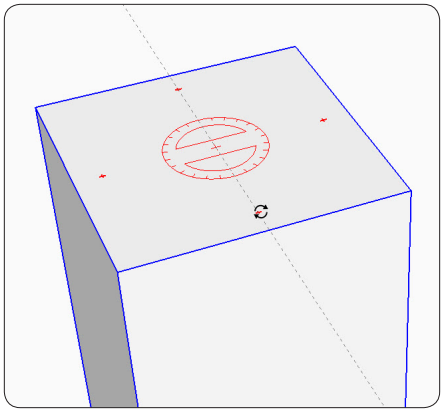


Figure 7. *Hovering over a face with the Move/Copy Tool changes the tool's function to allow you to rotate the component. You'll see a protractor and a new cursor appear on the face.*

Measurements Box and click the mouse to end the rotation. SketchUp hesitates at some angles, such as 90 and 180 degrees, making it easier to rotate to commonly used values. You can also place the Move/Copy Tool on any of

the other leg faces and rotate the component around the green or red axis.

SketchUp has a dedicated Rotate Tool, which is covered on page 71. The Rotate Tool operates somewhat differently and has more options. But for woodworking, the Move/Copy Tool can handle most rotations.

How to Copy a Component

The Move/Copy Tool also allows you to copy a component.

Choose the Move/Copy Tool and hover over the original component. (If that doesn't automatically select the component, use the Select Tool and then choose the Move/Copy Tool again). Press the keyboard Ctrl key (Option key on the Mac). A small plus sign will appear next to the cursor, which tells you that you are making a copy.

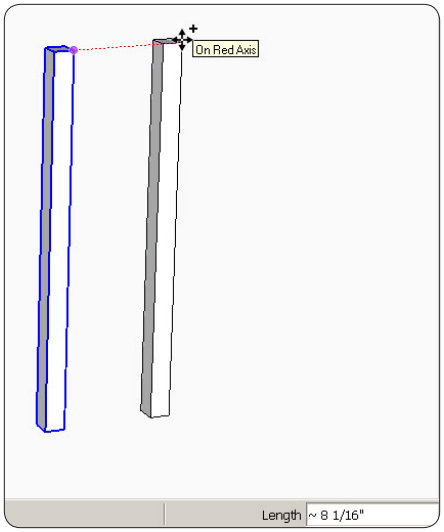


Figure 8. *Copying a component creates a duplicate, which you can place anywhere in the model. To place it precisely, type a value, which appears in the Measurements Box.*

Click on the component and begin to move the mouse. You will see a copy move with the mouse. Click the mouse button to stop the movement of the copy.

You can move the copy on any of the axes either by watching the dotted path trailing the copy (Figure 8) or by clicking the appropriate arrow key as you begin the move.

When you pick the Move/Copy Tool, the Measurements Box shows the changing distance of the move. The length is the distance from one corner of the original to the same corner of the copy. To move a copy a precise distance, type in the value, which will show up in the Measurements Box. Press the Enter key to place the copy where you want it.

How to Edit a Component

As you work on your design, you will soon want to edit the components. Here's how. Begin by creating a new component, which you will then edit. For this example, you'll create the component that will become a skirt for the tea table.

Make the component shown in Figure 9. Choose the Line Tool, click on the corner of the leg and draw a line along the red axis 22⅛ in. long. Continue a line 4 7⁄16 in. long, down along the blue axis. Next, draw a line back along the red axis until it intersects with the leg, then click the mouse button to end the line. Continue to draw a line up along the blue axis to close the face. You should see a blue rectangle like the one shown in Figure 9.

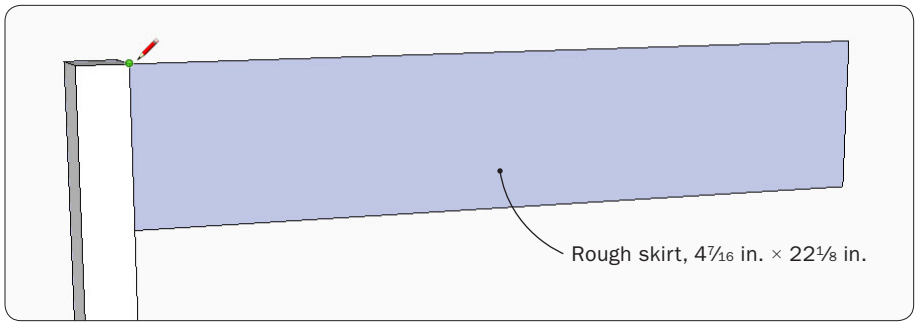


Figure 9. *Use the Line Tool to draw a face that you will then make a component.*

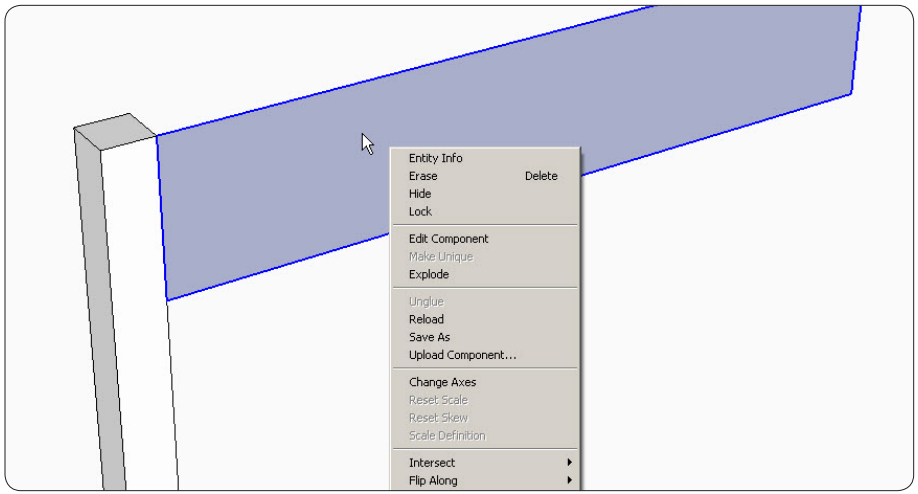


Figure 10. *Once you've created the new component, right-click on it to open a pop-up menu, then choose Edit Component.*

Make this shape a component. Double-click to select it. Then right-click on the selection and choose Make Component from the pop-up menu. When the next window appears, name the component and click the Create button. Now you have a skirt component. In the next step, you'll edit the component to give it thickness. I'll explain how to render the scroll shape and joinery in Chapter 13.

To edit the skirt component, choose the Select Tool and use the mouse to click on the component's face. That will highlight it in blue. Right-click on the component and select Edit Component from the pop-up menu (Figure 10).

When you select Edit Component, SketchUp places a dotted-line box around the component. All other components are paled out. This tells you that

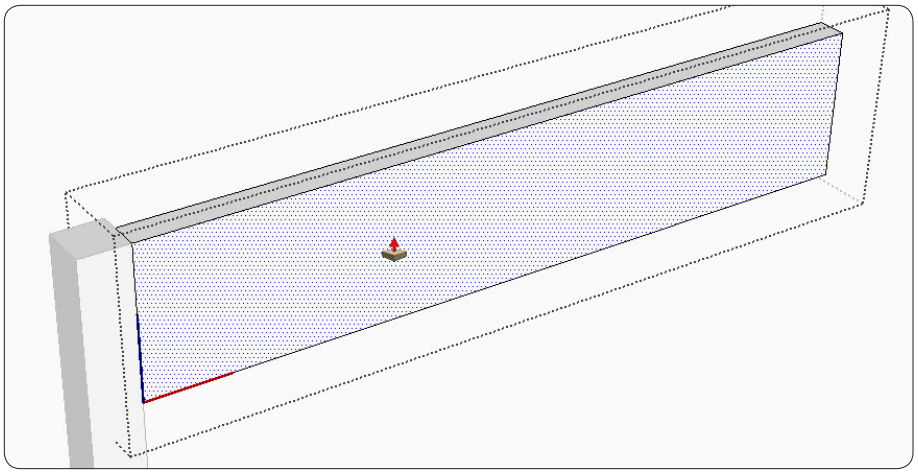


Figure 11. *Use the Push/Pull Tool to give the new component thickness. The dotted-line box around the component indicates that it is the only component available for editing.*

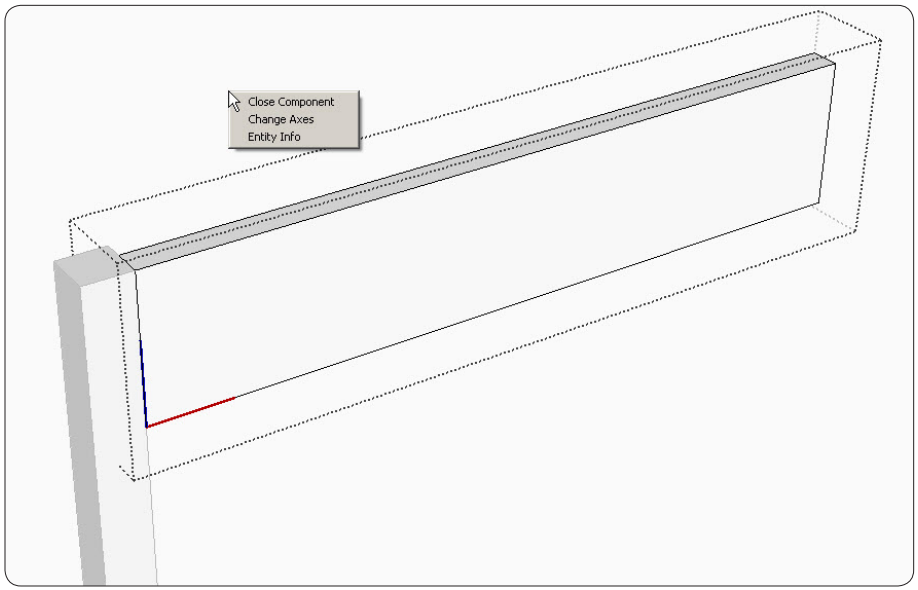


Figure 12. *To deselect the component, click the mouse anywhere outside the dotted-line box and use the pop-up menu.*

only the selected component is ready to be edited. Choose the Push/Pull Tool and push a thickness of ⅞ in. by typing ⅞ and then pressing the Enter key (Figure 11). You'll see the value appear in the Measurements Box.

When you have finished editing the component, right-click on an area of the model away from the box around a selected component. This will open a small pop-up box; choose Close Component from the list. That will immediately close the dotted-line box around the component, indicating that you are no longer in an editing mode (Figure 12).

How to Connect Components Accurately

Hands-on woodworking requires pieces to be positioned precisely and connected accurately, thus SketchUp provides a way to position and connect components precisely and accurately.

In furniture making and woodworking projects, separate pieces often connect or intersect at corners. The same goes in SketchUp; use the Move/Copy Tool to snap components together at corners or intersections. See how it works with the two components you've created for the tea table.

The top edge of the skirt is flush with the top of the leg, and the front face of the skirt is flush with the front face of the leg. That means the top corners of those two components are coincident when connected. For precise positioning, find matching connecting endpoints, corners, or intersections. Then use the Move/Copy Tool to connect the two points.

Choose the Move/Copy Tool and use it to pull the skirt a short distance away from its connection on the leg, as shown in Figure 13. Now, reconnect the two components precisely. Still using the Move/Copy Tool, click on the

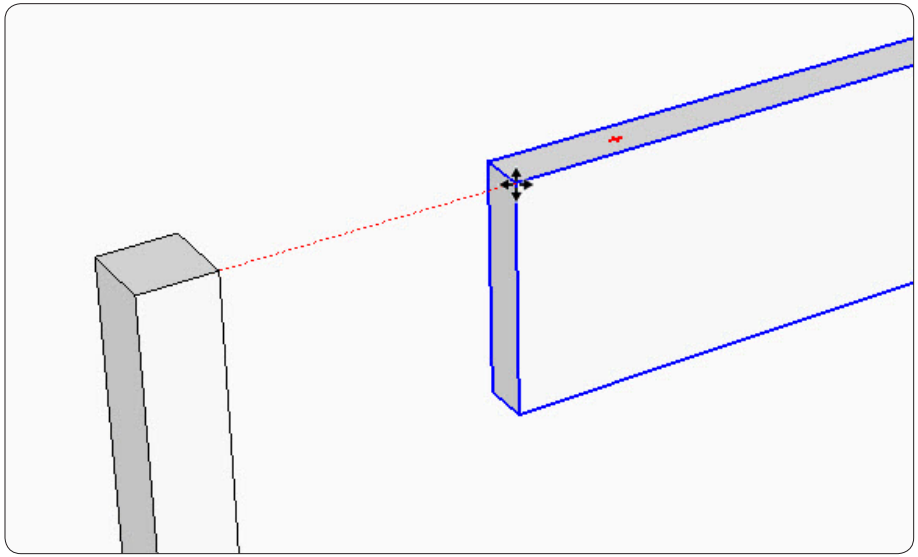


Figure 13. *Move the skirt away from its connection to the leg. The dotted red line shows that the component is moving on-axis.*

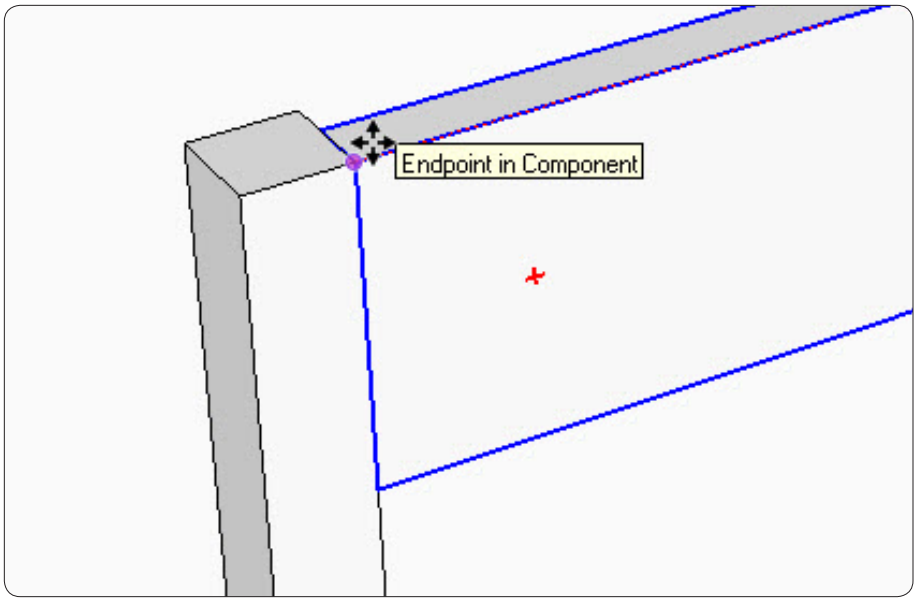


Figure 14. *Use the Move/Copy Tool to bring the two components together at the top corner of the leg. SketchUp will recognize that the components should join there and automatically position them.*

top front corner of the skirt, which will match up with the top corner of the leg. Move the mouse (and therefore the skirt) toward the leg. When you get close to the corner, SketchUp will recognize the connection and "grab" the corner of the leg, bringing the corners of the two components together precisely. Click the mouse to end the movement (Figure 14).

Sometimes, you won't have a common connecting intersection. In those cases, place a guide line or guide point where you want the connection to occur on one component. SketchUp will recognize a connection with a guide line or guide point, just as it will with a corner. Turned components don't have handy corners for connection. I often use centerlines to connect turned parts.

Often in furniture, mating pieces intersect along centerlines or midpoints. You can connect components that way in SketchUp. Suppose, for example, that the center of the skirt must be positioned at the center of the leg. Use the midpoint of the top edge of the skirt to connect to the midpoint of the leg.

Figure 15 shows the Move/Copy Tool attached to the midpoint of the skirt. SketchUp will always indicate that with a label that reads "Midpoint in Component" as you drag the mouse over an edge. Also note that the point inference will change color when you place the Move/Copy Tool at the midpoint.

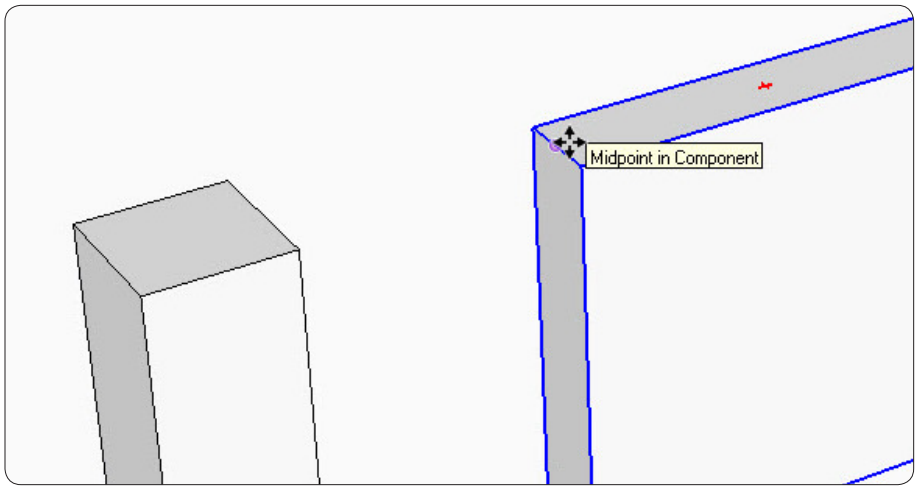


Figure 15. *You can grab the midpoint of a component with the Move/Copy Tool. SketchUp provides a label to tell you when the cursor is in the right place.*

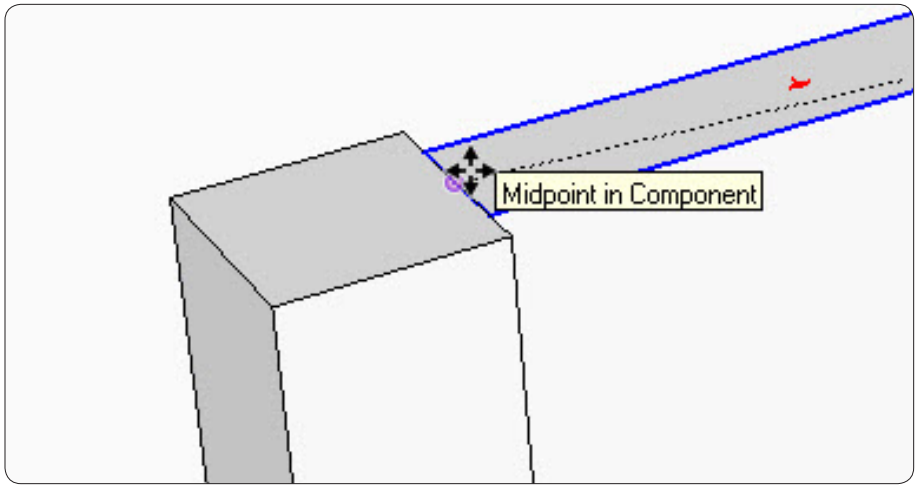


Figure 16. *You can connect components at their respective midpoints. SketchUp provides labels to tell you when you've made the connection.*

To connect the two components at their centers, choose the Move/Copy Tool and maneuver it to the midpoint of the skirt. Then move the mouse and skirt toward the center of the leg. You'll see the "Midpoint in Component" label when you reach the midpoint of the top edge of the leg, as shown in Figure 16. Click the mouse to end the move.

Create Your First SketchUp Model

It's time to practice using SketchUp's basic drawing tools. You'll create a model of the magazine rack shown in Figures 1 and 2. I've built more than a dozen of these modular, stackable racks to hold my library of woodworking magazines. It's a nice project and also a good SketchUp practice model. The exercise will help you become adept in the following essential SketchUp skills:

- Staying on axis.
- Drawing to precise lengths.
- Placing temporary guide lines.
- Building, editing, copying, and connecting components.
- Using the Push/Pull Tool.
- Using the Arc Tool.

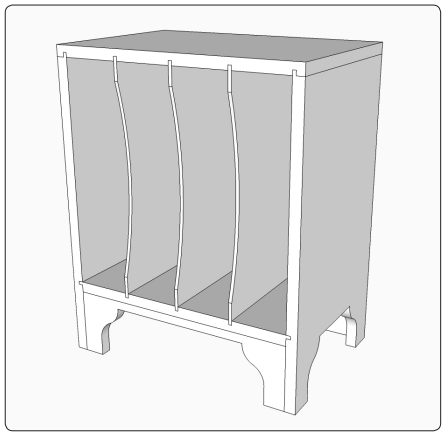


Figure 1. *A simple modular magazine rack makes a good SketchUp practice model.*

The exercise also shows you how to develop a model as an integrated unit. That is, you create and shape individual components where they fit in the finished piece, properly oriented horizontally and vertically. This method of working saves time by eliminating the need to make many separate measurements. It also helps you develop an accurate model.

Because this is the first complete modeling exercise, you may not get the results you want the first time you try to draw a shape or move a component. If that happens, back up and try again. If you're unsure about how to use a tool or execute a command, flip back to the appropriate chapter to refresh your memory.

Figure 3, on p. 30, is an orthographic drawing that shows top, end, and front views with overall dimensions. Print this view and keep it nearby for reference while you re-create the model.

Step 1 Use the Line Tool to create a rectangle forming one edge of the side. It's easiest to draw on the green and blue axes to make the rectangle the proper height and width. Use the Push/Pull Tool to make the piece ⅝-in. thick. Use the Select Tool to draw a Selection Box around the object, right-click, and choose Make Component from the pop-up menu. Name the component Side (Figure 4).

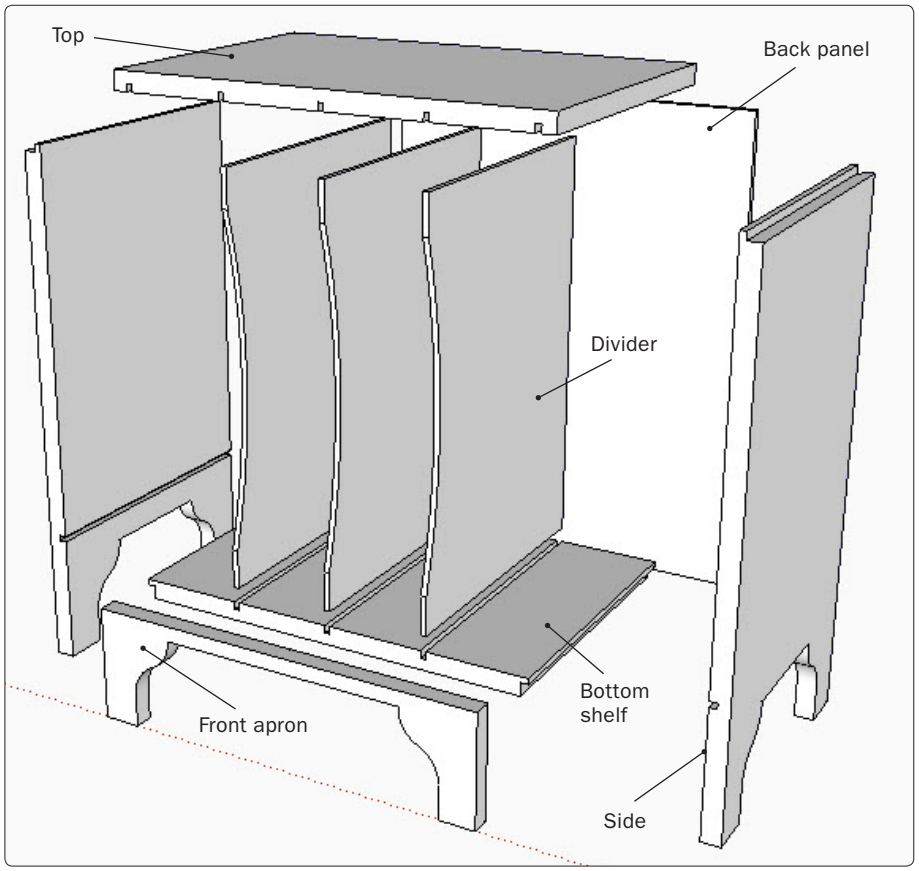


Figure 2. *The components of the magazine rack.*

Step 2 Use the Tape Measure Tool to place a guideline along the red axis to help you position a copy of the side component. Use the Move/Copy Tool to copy the side component and move it into position on the guide line.

You also have to mirror the copy so the joint details you'll draw later will be properly oriented on the inside face of the side. The Flip Along function (see "Flip Along Function" on p. 31), executes this mirroring operation. To execute Flip Along, right-click on the copied side, then choose Flip Along Red Axis from the pop-up menu (Figure 5).

Step 3 Using the Line and Push/Pull Tools, create the top and bottom components in the same manner as you created the sides. Begin by creating the top with the Line Tool: Draw over the overall boundary corner to corner on the out-

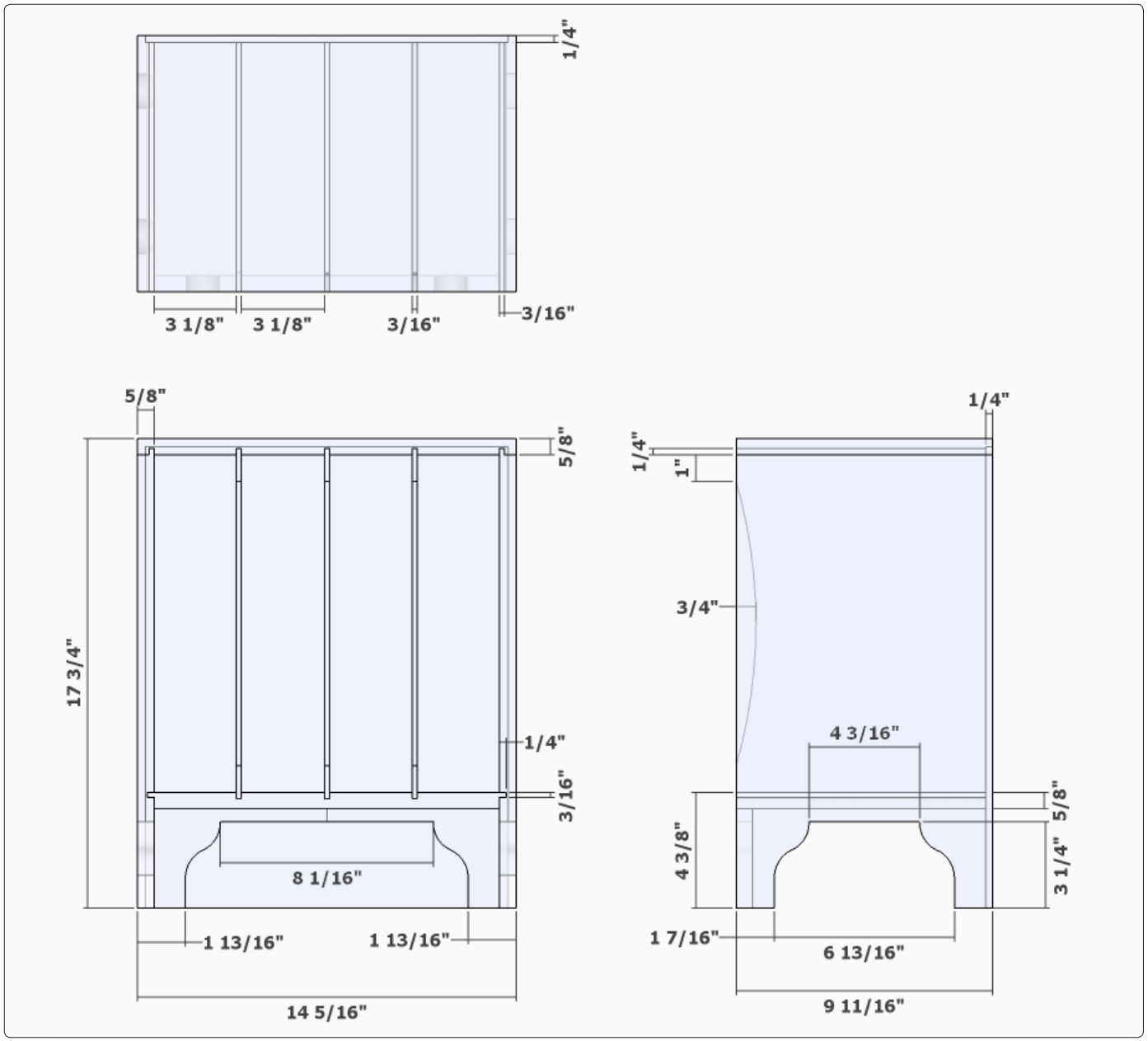


Figure 3. *Front, side, and top views of the magazine rack.*

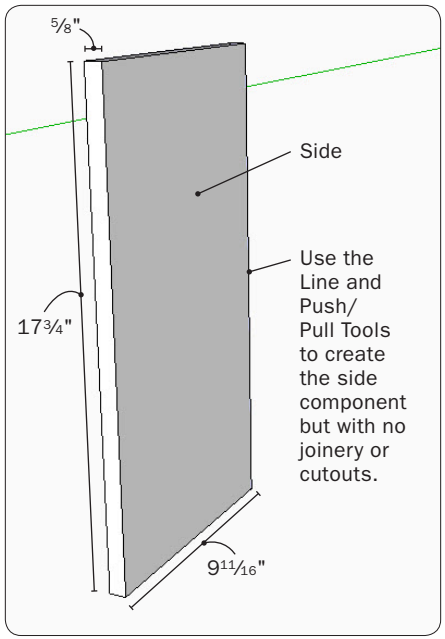


Figure 4. *Begin by making the side component.*

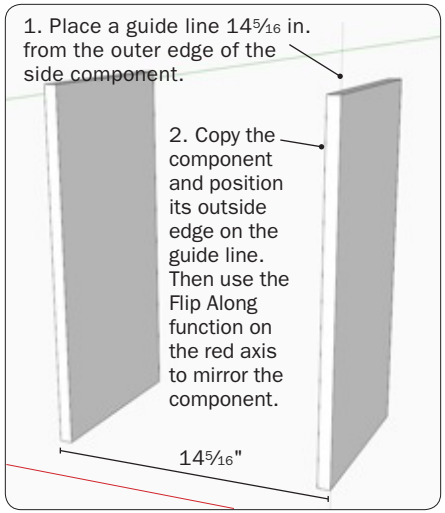


Figure 5. *Copy the side component and flip it so that the joinery you add later will be properly oriented.*

The Flip Along Function

The Flip Along function is one of the most confusing for newcomers to SketchUp. But it's a feature that's hard to avoid in woodworking because we continually flip, or mirror, components in our furniture. For example, all four legs of a table may be identical except for the orientation of the joinery. Using the Flip Along function on copies of one leg component mirrors them so that each is properly oriented in the overall design. It's extremely powerful and time-saving to draw only one leg design, then copy and flip it to create a full complement of legs, all with joinery properly oriented. If I edit any one of the leg components, all the copies are instantly updated with the change, and the changes will be properly oriented.

SketchUp's Rotate Tool is not a substitute for the Flip Along function. A rotation does not mirror a component, so it won't produce a component with properly oriented details.

There is a choice to make every time you use the Flip Along function: Do you flip along the red, green, or blue axis? It's not always clear which one to choose.

The Flip Along function is executed on the component's axis, which is based on its orientation when first created. You can check the component's axis by checking a box in SketchUp at Window > Model Info > Components > Show Component's Axis.

You can avoid much of the confusion about axes by creating components in their actual position within the model. In the case of the magazine rack, you create one side in its proper position and position the copy along the same axis so that it, too, is properly oriented. Thus, since you move the copied side along the red axis, you execute the Flip Along function along the red axis, too.

side top edges of the side components. Then use the Push/Pull Tool to make the top 5/8-in. thick. The top will overlap the sides at the joint locations. Draw a Selection Box around the top and, as you did with the side, make it a component and name it Top. Use the Tape Measure Tool to place a guide line 4 3/8 in. from the bottom of one side. Use that guide line to draw the front edge of the bottom component, then use the Push/Pull Tool to make it 9 11/16-in. deep. As with the top component, be sure this one overlaps the sides. When you are finished, draw a Selection Box around the part, make it a component, and name it Bottom (Figure 6).

Step 4 The next step is to create the tongue-and-groove joints in the side, top, and bottom components.

Zoom in close to the upper right corner, as shown in Figure 7. Place guide lines with the Tape Measure Tool to show the height and width of the groove in the top component. Use the Line Tool to trace over the guide lines to form the tongue and shoulder on the side component. Then use the Push/Pull Tool to remove the waste; hover over the waste portion, then click the mouse, move the cursor to the back edge of the component, and click again.

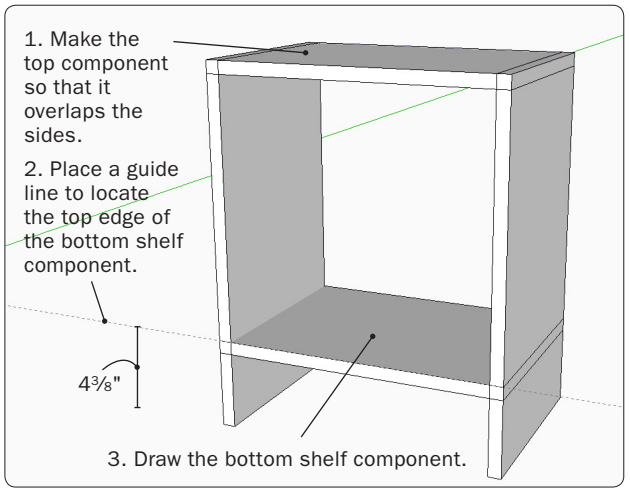


Figure 6. *Make the basic shapes for the top and bottom shelf components. You'll add joinery later.*

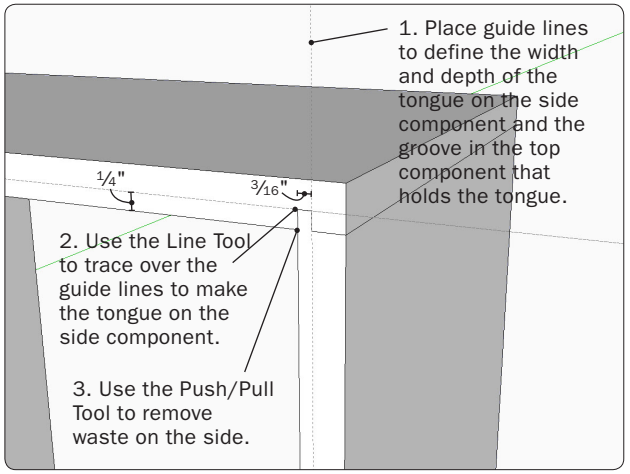


Figure 7. *Creating joints involves selecting one component, using the Line and Push/Pull Tools to create half the joint, selecting the adjacent component, and creating the mating half.*

Click on the side component to select it and pick Edit Component from the pop-up menu. Use the Line Tool to trace over the guide lines to make the tongue shape. If you've drawn this half of the joint correctly, only the waste portion will be highlighted when you hover over it with the Select Tool or the Push/Pull Tool. Then use the Push/Pull Tool to

clear out the waste, forming the tongue along the top edge of the side. Zoom out and you will see that both sides now have a tongue; and because you flipped the copy to mirror it, the tongues on both sides are properly oriented.

Next, select the top component and choose Edit Component from the pop-up menu. Use the Line Tool to trace over the tongue to begin creating its mating groove. Use the Push/Pull Tool to push the groove all the way to the back edge. The easiest way to remove all the waste is to click on the back edge of the component with the Push/Pull Tool; no need to type in a dimension.

Repeat those actions to complete the tongue and groove joint at the opposite end of the top component.

Repeat those actions two more times to make the tongue-and-groove joints on the bottom and side components. The procedures are the same, but as Figure 3 shows, the tongue and groove are oriented differently.

Step 5 Right-click the side component and choose Edit Component from the pop-up menu. Use the Tape Measure Tool to place guidelines that will help you shape the ogee cutout on the side components. Follow the dimensions shown in Figure 8.

Use the Line Tool to draw an angled line along the path of the ogee curves. Use the Arc Tool to draw two arcs from the endpoints to the midpoint of the angled line, as shown in Figure 8. Apply a 3⁄16-in. bulge to each arc. (As you begin moving the cursor, type 3/16 to set the bulge.) Use the Line Tool to draw the straight horizontal and vertical lines to complete the shape, as described in Figure 8.

Step 6 Use the Eraser Tool to delete the angled line on the path of the ogee curve. Use the Move/Copy Tool to copy the shape you just drew (Figure 9).

Step 7 Use the Flip Along function to mirror the copy of the shape. Then use the Move/Copy Tool to connect the copied shape to the original one at the centerline. Zoom in close to be sure that the two shapes connect on the centerline at the base of the component. Double-click the mouse on the half shape, right-click on the selection, and choose Make Component from the pop-up menu. In the Make Component pop-up box, do not check the box that says "replace selection with component." Name it Ogee Shape. This component will be used later for shaping the front skirt component (Figure 10). SketchUp automatically saves the component; you can easily retrieve it and use it later to help shape the front skirt.

Step 8 Use the Eraser Tool to delete the centerline, then use the Push/Pull Tool to push out the center of the cutout (Figure 11).

Step 9 Use the Line Tool to draw the boundary of the front skirt, as shown in Figure 12. Then use the Push/Pull Tool to make the skirt 5⁄8-in. thick.

Step 10 Use the Tape Measure Tool to place guide lines on the front skirt, as

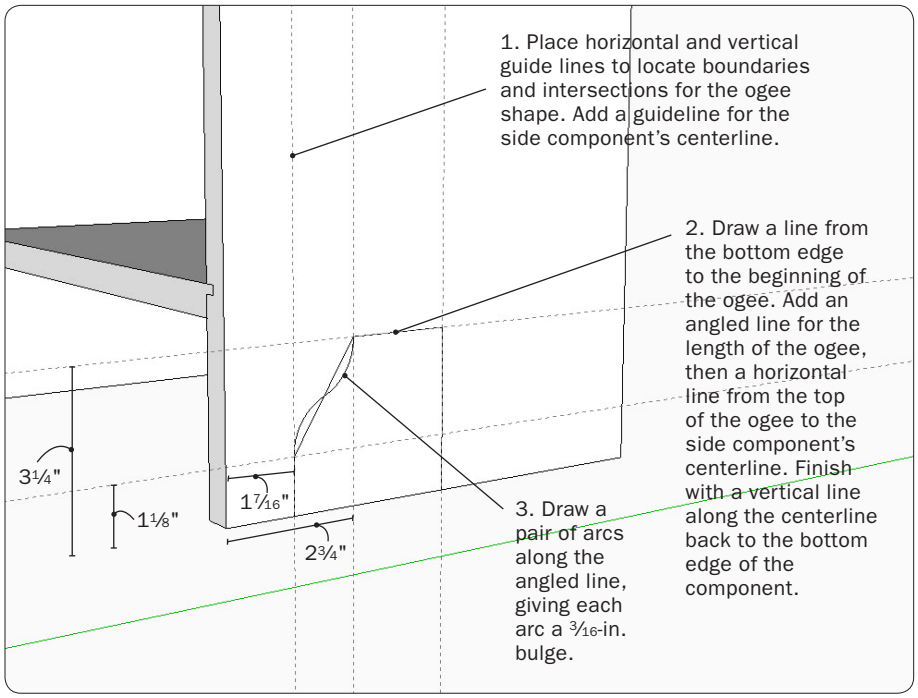


Figure 8. *You need to draw only one ogee-shaped cutout. You copy and flip it to add the rest to the model.*

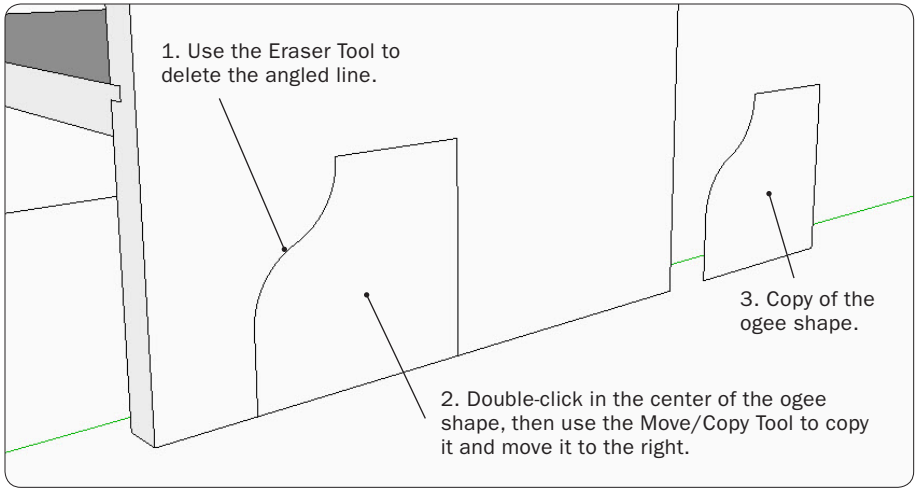


Figure 9. *Clean up the ogee shape and copy it.*

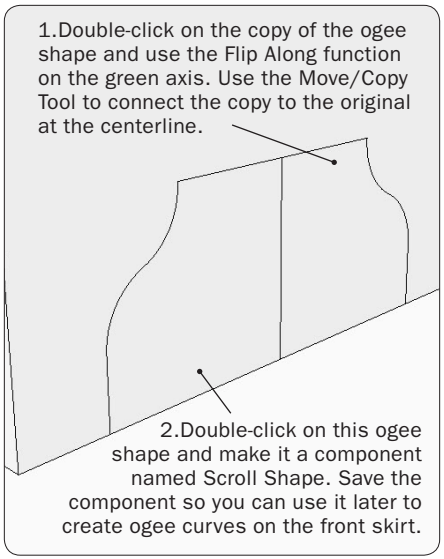


Figure 10. *Flip the copy of the ogee shape and connect it to the original.*

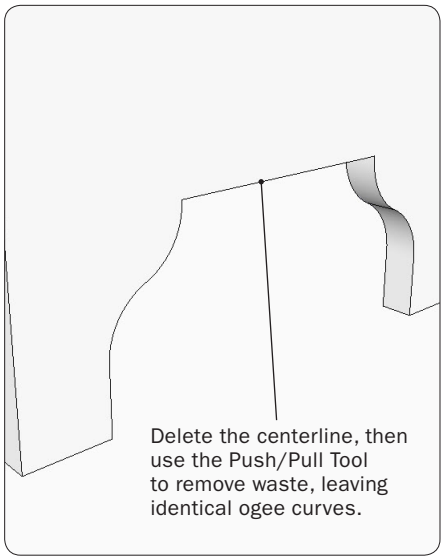


Figure 11. *Complete the ogee curves on the side components.*

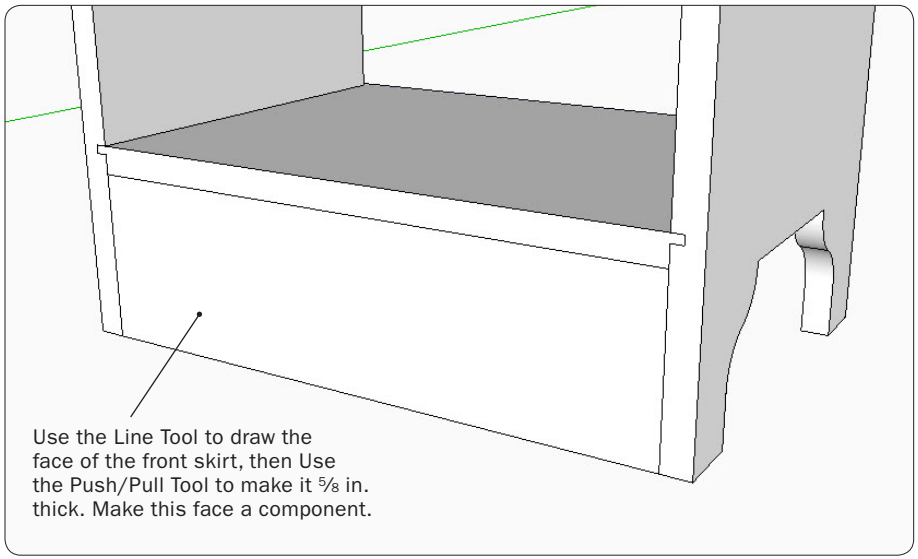


Figure 12. *Draw the rough shape of the front skirt.*

shown in Figure 13, to help you position the ogee shape cutout. Open the Component Dialog Box (click on Window in the Menu Bar and pick Components from the menu), and click on the ogee shape component created in step seven. Hover over the top edge of the ogee shape component. Move the mouse over one of the plus signs, and a protractor will appear. Click the mouse and start the rotation. Click again when the component has rotated 90 degrees. To rotate the shape successfully, you may have to orbit around so that you're looking down on it; zoom in close for a good view. Hover as slowly as you can until the plus signs appear.

Step 11 Use the Move/Copy Tool to move the ogee shape component into position on the guide line. Copy the shape and use the Flip Along function to orient and position the copy on the other guide line. Now, you need to make the ogee shape components a part of the front skirt component. To do that you have to explode, or un-make them as separate componments, then make a new, combined component. Right-click on each ogee shape component and choose Explode from the pop-up menu. Right-click on the front skirt component and choose Explode from the pop-up menu. Use the Select Tool to select all of the front skirt, including the two shapes. Right-click on the selection and choose Make Component from the pop-up menu. Name the component Front Skirt, and check the box to replace the previous component definition (Figure 14).

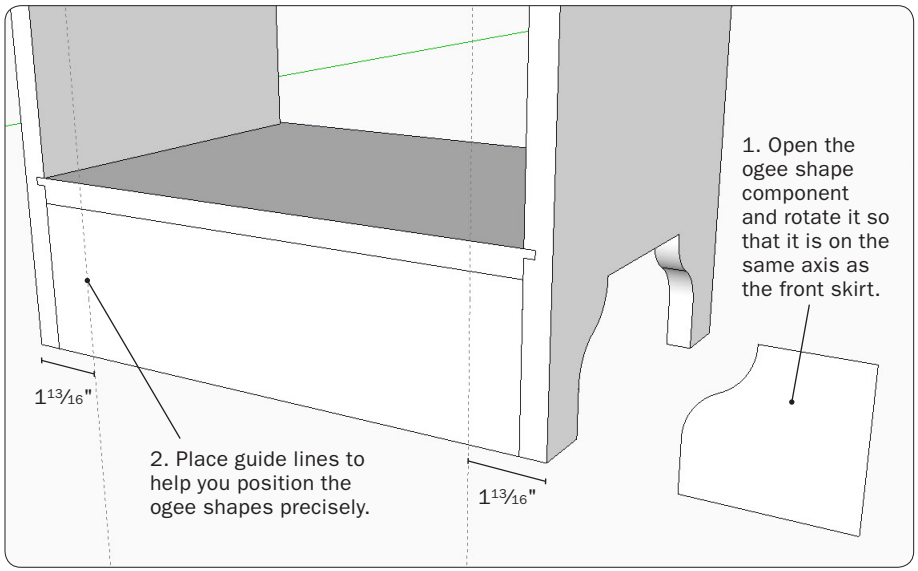


Figure 13. *Add ogee curves to the front skirt.*

Step 12 Open the front skirt component for editing. Complete the cutout on the front by using the Line Tool to add a horizontal line connecting the two ogee shapes. Then use the Push/Pull Tool to remove the waste.

Use the Tape Measure Tool to place guide lines that define the width and depth of the partition grooves in the bottom component. Use Figure 3 and Figure 15 to find the proper dimensions. Use the Line Tool to outline the shape of the grooves on the front edge of the bottom component. Then use the Push/Pull Tool to push out the grooves to the back edge of the component. Repeat these steps to make the grooves in the top component.

Step 13 With the Line Tool, draw the front face of the partition so that it fills the front of the grooves on the top and bottom components, as shown in Figure 16. Double-click on the shape to select it, then right click and choose Make Component from the pop-up menu. Name the component Partition.

Step 14 Use the Push/Pull Tool to push the partition component to the same depth as the bottom component. Place guide lines for the endpoints of the cutout in the partition, as shown in Figure 17. Then select the Arc Tool and use it to draw an arc that has a ¾-in. bulge between the guide lines on the side of the partition.

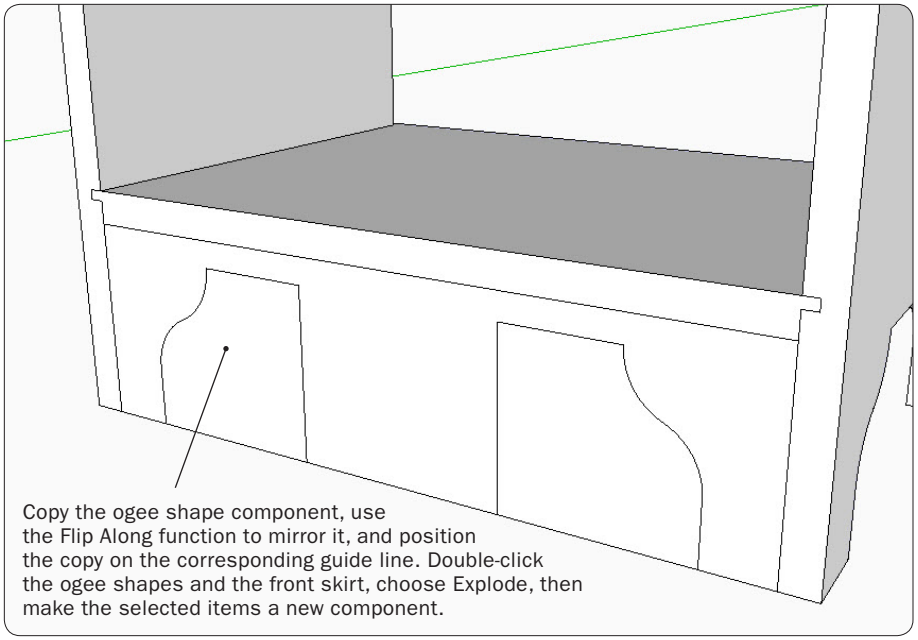


Figure 14. *Complete the ogee curves on the front skirt.*

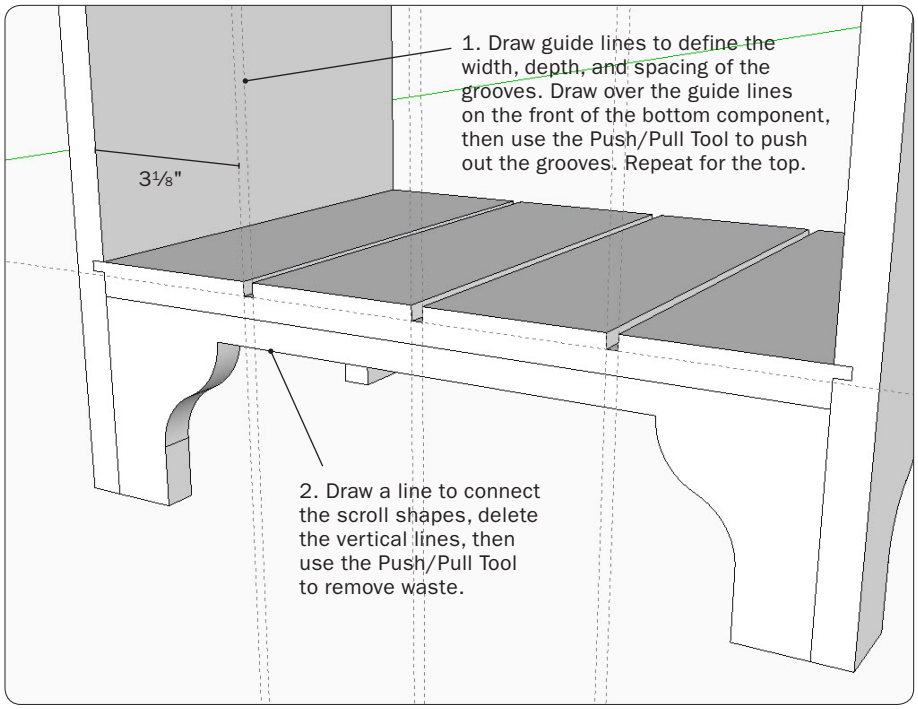


Figure 15. *Finish the front skirt and add grooves in the top and the bottom shelf.*

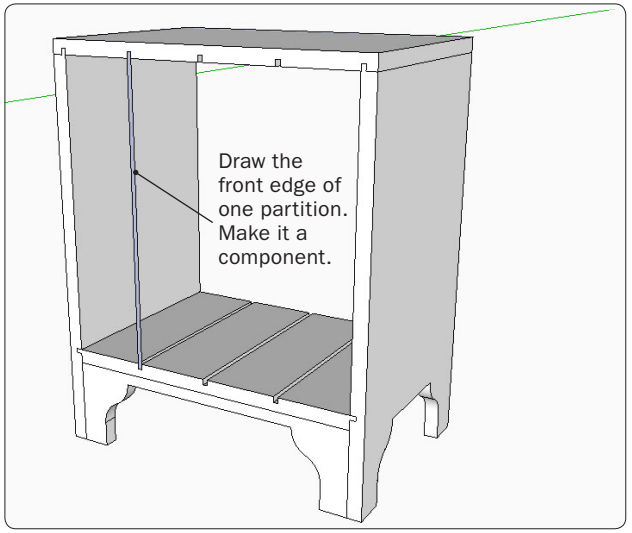


Figure 16. *Begin drawing the partition component.*

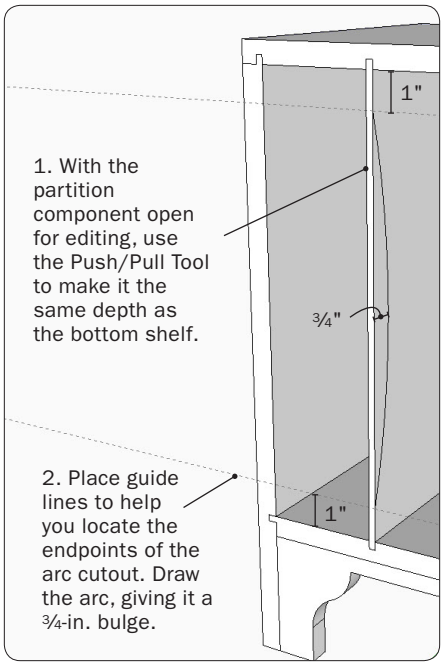


Figure 17. *Begin shaping the partition.*

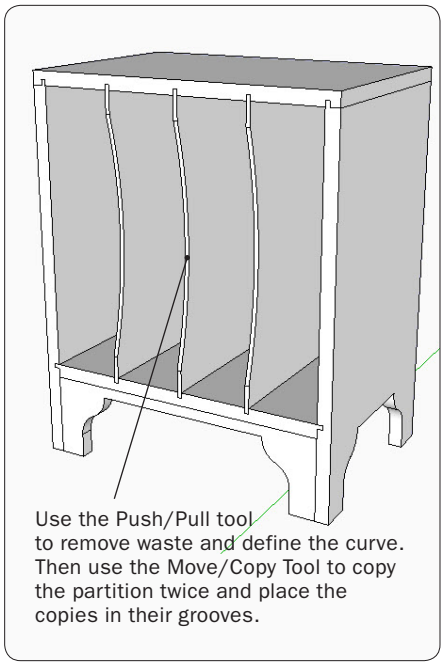


Figure 18. *Complete and copy the partition.*

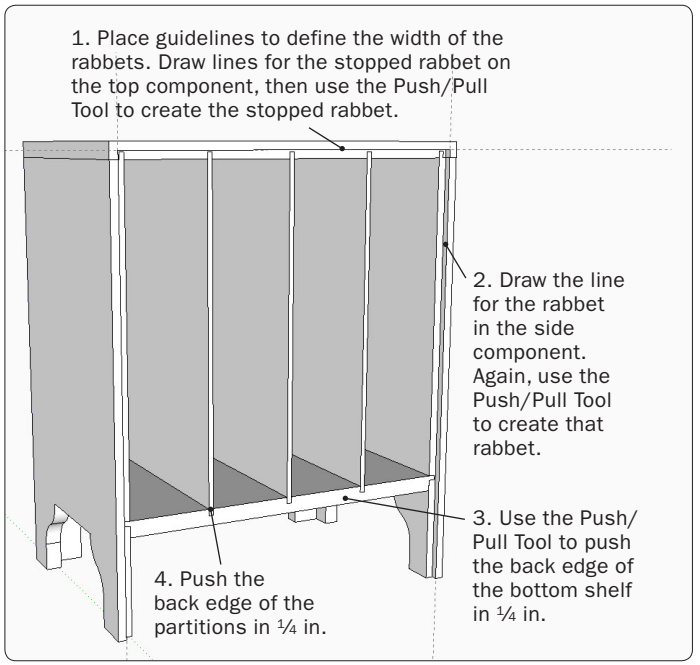


Figure 19. *Rabbet the top and side components to house the back panel.*

Step 15 Use the Push/Pull Tool to create the arc cutout in the partition. Use the Move/Copy Tool to make two copies of the partition and place them in their grooves (Figure 18).

Step 16 Use the Orbit Tool to view the back of the model. Use the Tape Measure Tool to place guide lines on the top and side components, marking the width of a rabbet for the back panel. (It will be a stopped rabbet on the top.) Refer to Figure 3, and select the top component. Use the Line Tool to place lines for the stopped rabbet joint. Use the Push/Pull Tool to push the rabbet to its ¼-in. depth. Similarly, select a side component, draw a line for the rabbet on the full length of the piece, and use the Push/Pull Tool to push it to the proper depth. Use the Push/Pull Tool to push the back edge of the bottom piece ¼ in., to align with the rabbet in the side component. Do the same to push one of the partitions back to align with the bottom component—changing all three partitions (Figure 19).

Step 17 Use the Line Tool to draw the face of the back panel, fitted inside the rabbet. Make it a component and name it Back Panel. Edit the component and use the Push/Pull Tool to make it ¼ in. thick (Figure 20). This completes the model of the modular magazine rack.

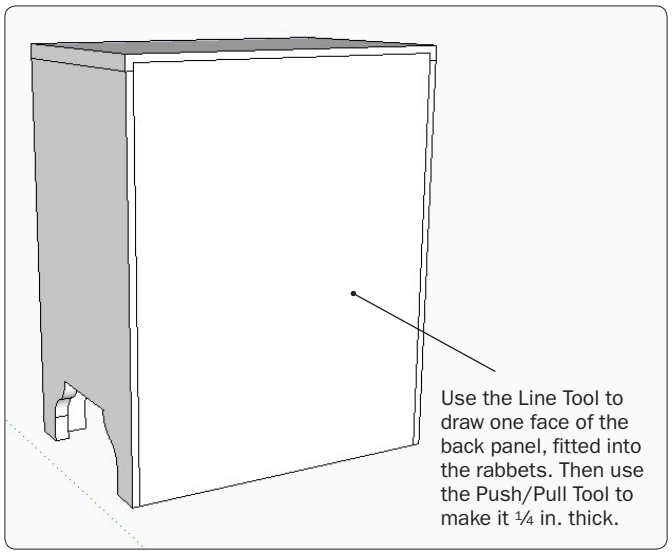


Figure 20. *Create the back panel and you're done.*

How to Design and Construct Joints

SketchUp gives you the ability to quickly and accurately detail woodworking joints. That's a great advantage. Woodworkers spend much of their shop time sawing, chopping, routing, drilling, shaping, shaving, and fitting joints. An inaccurate joint design inevitably leads to frustrating rework. But when you design joints in SketchUp, you can inspect their details from any angle. Any discrepancies or poorly fitting parts will quickly be apparent. SketchUp even has an X-Ray capability, allowing you to look inside a joint.

Once you have designed a joint, you can use SketchUp to produce full-size templates. I find that I make fewer errors in the shop if I work with templates. They are especially helpful when making dowel or dovetail joints.

In this chapter, I'll show you how to use SketchUp to create mortise-and-tenon and dovetail joints. You can use the procedures you learn here to create other joints, such as bridle and tongue and groove.

The Right Time to Detail Joints

I find it best to postpone drawing joint details until I have the basic overall assembly of component pieces in place. This is particularly true when developing a new piece of furniture. Work out the overall proportions and the sizes of components first. Just butt pieces together temporarily, then add the joint details.

If you try to draw joints at an earlier stage of development, it will be harder to adjust component sizes and thicknesses. Premature design of joints will leave you with more rework.

The Mortise-and-Tenon Joint

There must be hundreds of variations on the mortise-and-tenon joint: haunched, two shoulders, no shoulders, blind, through, wedged, pegged, and so on. You can create any of those variations in SketchUp with the procedures and tools shown in this exercise.

We'll use the skirt and leg for the square tea table in Chapter 6. If you didn't save those drawings, redo them now.

The tenon is ¼ in. thick, centered on the end of the skirt, and ¾ in. long, with a ½-in. shoulder at the top edge (Figure 1).

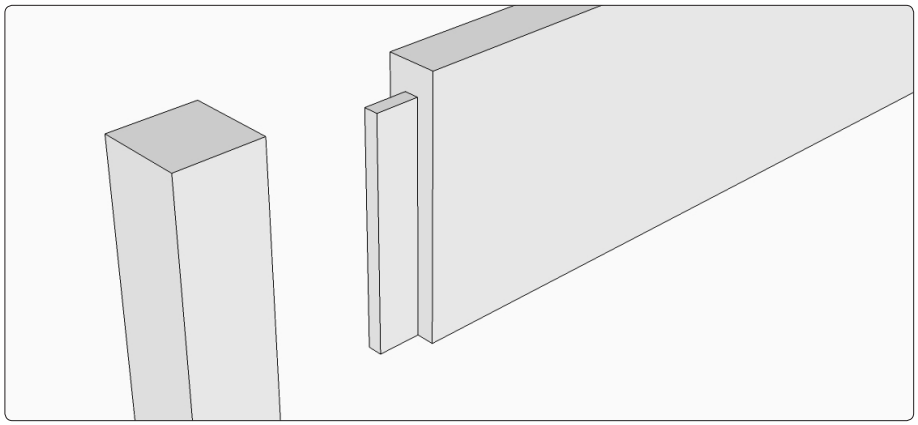


Figure 1. *The mortise-and-tenon joint you'll duplicate in this chapter.*

Step 1 Select the Tape Measure Tool and click on the front vertical edge of the skirt. (You don't have to select or edit the skirt component to place these temporary guidelines; you'll erase them later.) Move the guide line along the green axis, toward the center of the skirt. As Figure 2 shows, you'll see a point appear where you clicked on the edge, and a green dotted line to show that you're on the green axis. As you move the guide line toward the center of skirt, hover the mouse over the midpoint. A magenta inference point will appear when you are exactly on the midpoint. Click the mouse to place the guide line.

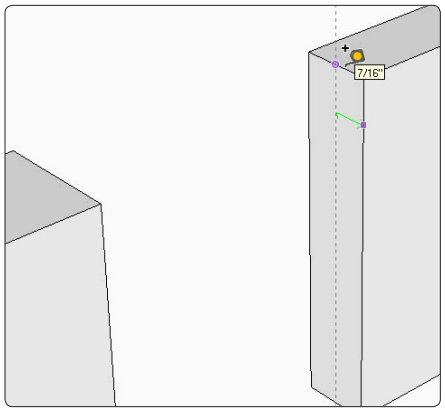


Figure 2. *Use the Tape Measure Tool to place a guide line at the midpoint of the skirt component.*

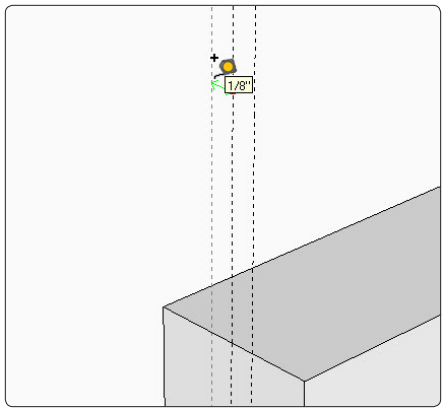


Figure 3. *Place two guides on either side of the centerline to define the thickness of the tenon.*

Use the Tape Measure Tool to place two additional guide lines ⅛ in. to each side of the midpoint guide line, as shown in Figure 3. Be sure you move the tool along the green axis. To place the guide lines precisely, type ⅛ and press

the Enter key. These guide lines indicate the thickness of the tenon.

Place one additional guide line, to define the tenon height. Use the Tape Measure Tool to click on the top edge of the skirt and place a guideline ½ in. down from the top (Figure 4).

Step 2 Right-click on the skirt component and choose Edit Component from the pop-up menu. (Note that the guide lines become pale once you select the component. That's because anything that's not part of the component you are editing is faded out.) Use the Line Tool to trace over the guide lines, drawing the boundary of the tenon, as shown in Figure 5. SketchUp will flag intersections to help you place the lines accurately. A typical mistake is to forget the Edit Component step and build the tenon in place but not as part of the component. Everything will look normal. But when you move the skirt component, the tenon will stay behind. Or when you copy the skirt, the copy will not have the tenon.

Step 3 Choose the Push/Pull Tool. Hover over the tenon shape, and notice how it's highlighted with a pattern of blue dots. Click the mouse and begin pulling the tenon outward. To quickly make the tenon the proper length, type ¾, which will appear in the Measurements Box, and press the Enter key (Figure 6).

One skirt tenon is complete. Now, an identical tenon needs to be added to the other end of the skirt. You could repeat the drawing steps, but it's faster to copy this tenon and paste it on the skirt.

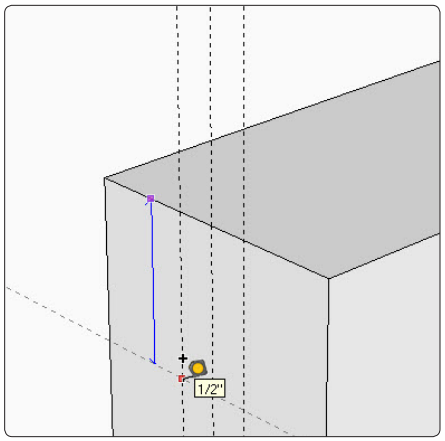


Figure 4. *Place one more guide line to define the height of the tenon.*

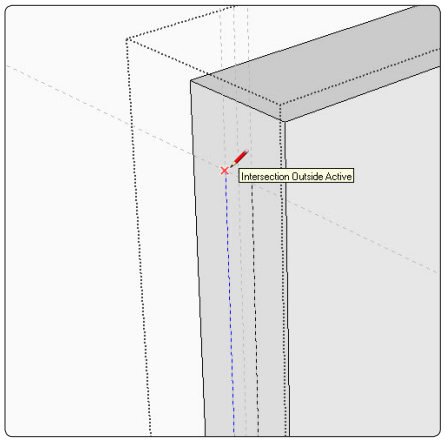


Figure 5. *Use the Line Tool to trace over the guide lines.*

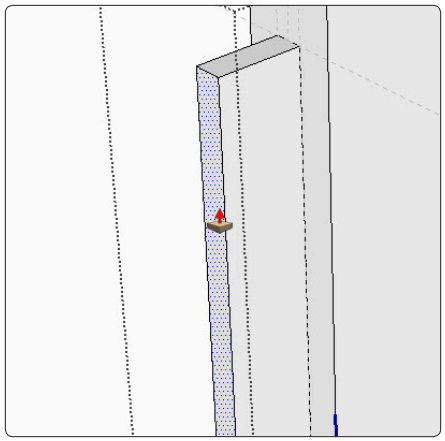


Figure 6. *Use the Push/Pull Tool to give the tenon the proper length.*

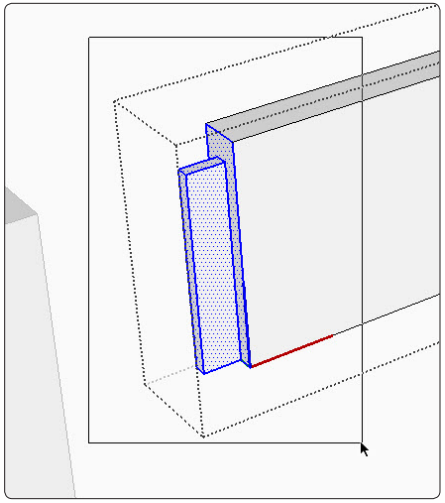


Figure 7. *Draw a left-to-right Selection Box to highlight the tenon so you can copy it.*

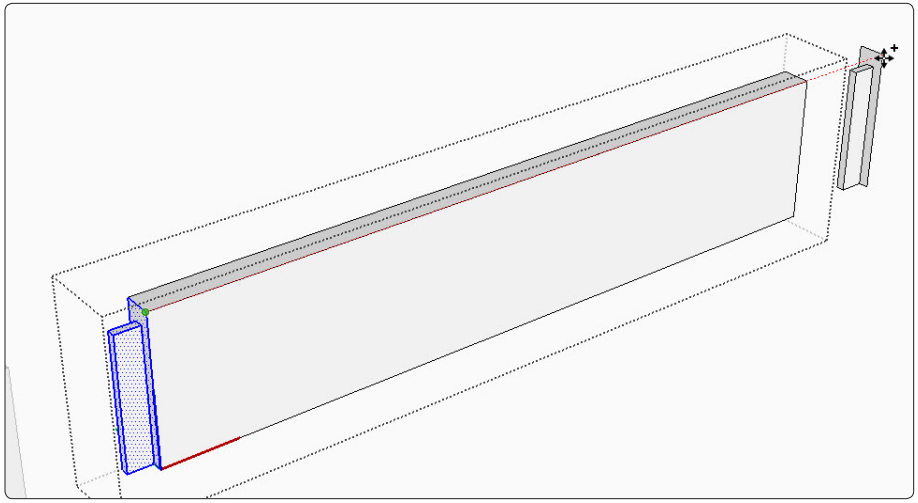


Figure 8. *Use the Move/Copy Tool to copy the tenon and move it past the opposite end of the skirt component.*

Step 4 Right-click on the skirt component and choose Edit Component from the pop-up menu. Select only the tenon by using the Select Tool to draw a left-to-right box around the tenon and the end of the skirt component, as shown in Figure 7. The selection will also take in the end face of the skirt, which is fine.

Step 5 Choose the Move/Copy Tool and push the Ctrl key (Option key on the Mac) to make a copy of the tenon. You'll see a plus sign next to the cursor, indicating that you're copying something. Click on the tenon and move the copy to the right, along the red axis. Click the mouse to stop the movement of the copy just beyond the right end of the skirt, as shown in Figure 8.

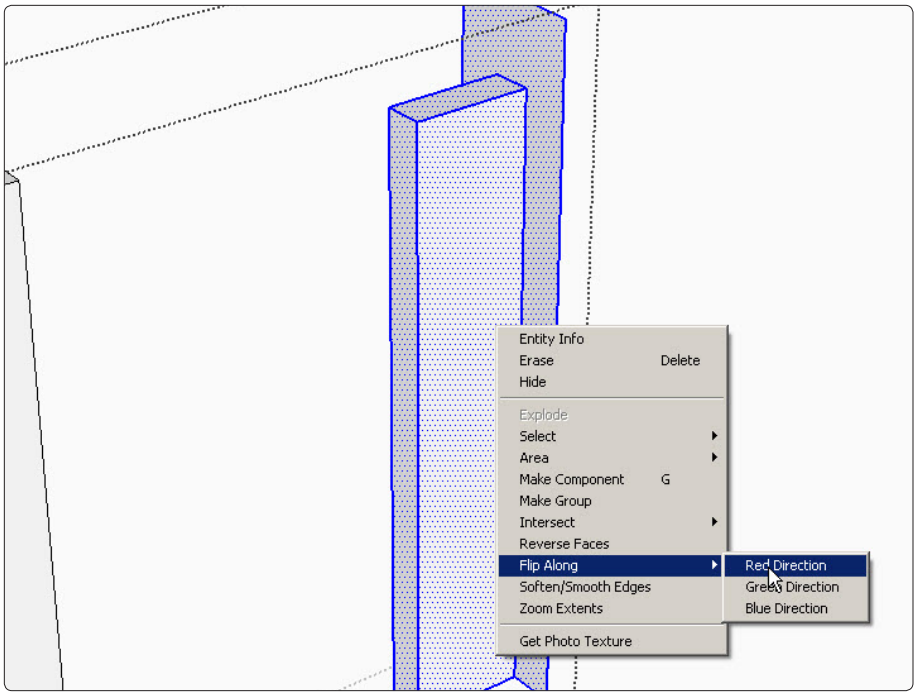


Figure 9. *The pop-up menus that lead you to the Flip Along function, which lets you mirror a copy so that it is oriented properly in the model.*

Step 6 Now you have to orient the copied tenon properly. As shown in Figure 9, right-click on the copied tenon. Choose Flip Along from the pop-up menu. This will open a second menu, listing the three axis directions. Click on Red Direction. This will immediately flip the tenon copy to its proper orientation, as shown in Figure 10.

Step 7 Select the Move/Copy Tool, grab the corner of the tenon copy, and connect it to the corresponding corner of the skirt, as shown in Figure 11. Click the mouse to fix the location of the copied tenon. You may wonder what happens to the duplicated face of the skirt end that accompanied the tenon. SketchUp automatically eliminates duplicate faces. You may need to fill in a missing face, however. See Figure 10.

Step 8 Now that the tenon is complete, you're ready to make the matching mortise in the leg. There are many ways to do that, but I think it's best to use the tenon to make the mortise. This method greatly reduces the risk of errors and forces the mortise to match precisely with the tenon.

Use the Move/Copy Tool to attach a corner of the skirt to the corresponding

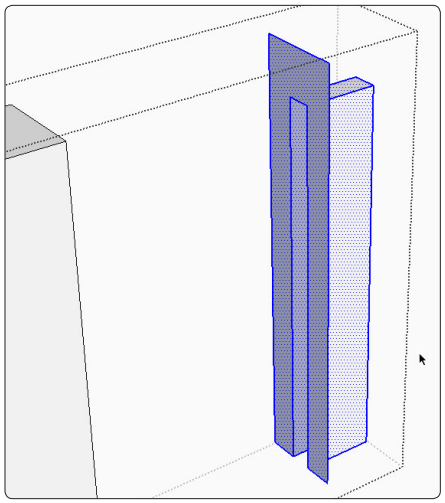


Figure 10. *The tenon once it has been flipped along its red direction.*

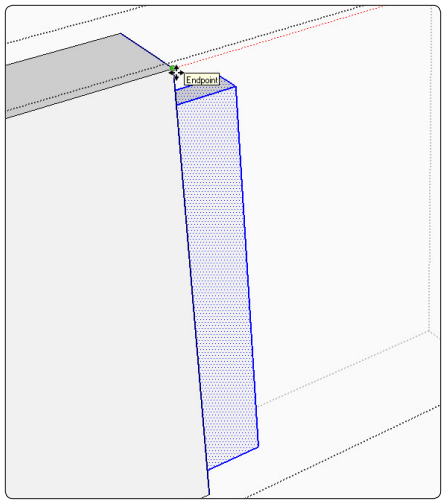


Figure 11. *The tenon copy moved into place. Once its position is fixed with the Move/Copy Tool, it becomes part of the skirt component.*

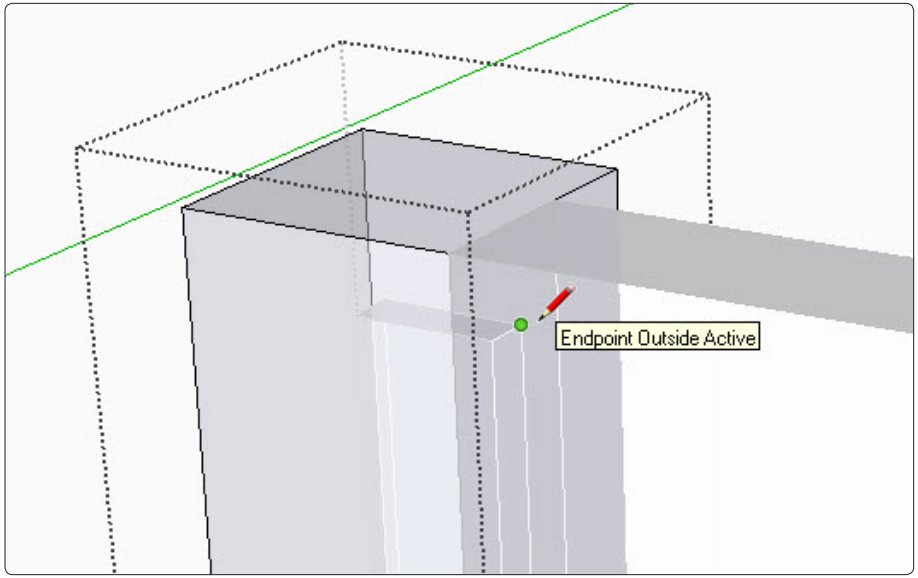


Figure 12. *X-Ray View opens up the components so you can see through them. This feature lets you use the boundary of the tenon, which would normally be hidden, to trace the outline of the mortise.*

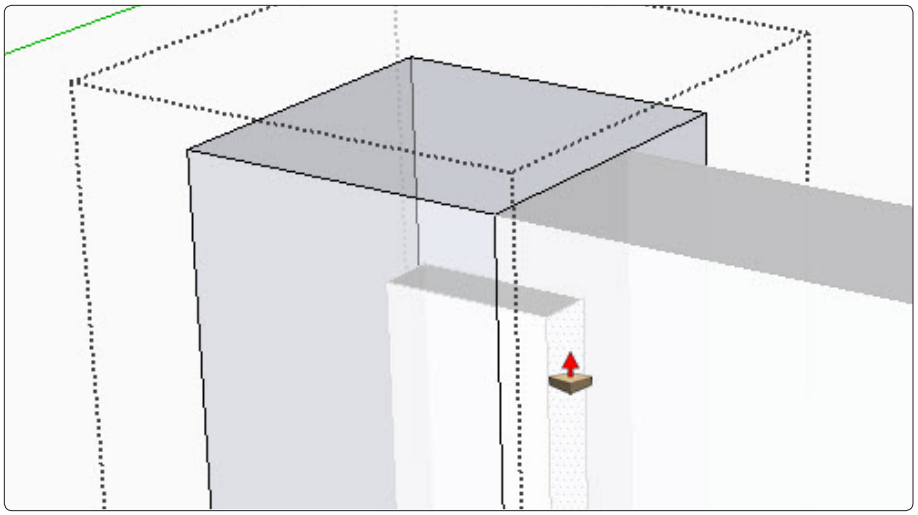


Figure 13. *In X-Ray View, you can use the Push/Pull Tool to make otherwise out-of-sight parts of a joint the proper size. Here, you can click on the back edge of the tenon to set the depth of the mortise.*

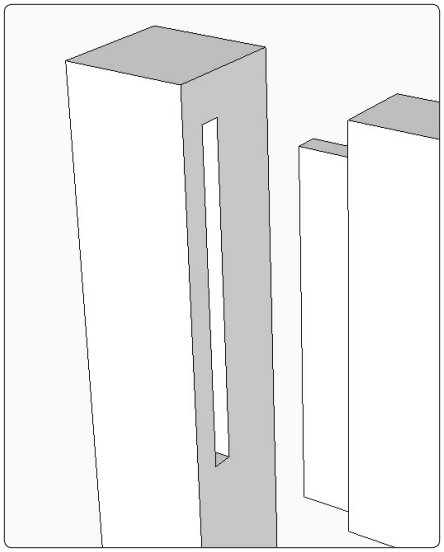


Figure 14. *The finished mortise-and-tenon joint. By using the tenon to shape the mortise, you can be sure the halves of the joint align perfectly.*

corner of the leg, as shown in Figure 12. Right-click on the leg component and choose Edit Component from the pop-up menu. Click on the X-Ray icon in the horizontal Face Style Toolbar at the top of the screen.

Step 9 Zoom in close to the model. Note how in the X-Ray view the boundary of the tenon, where it intersects with the face of the leg, shows up as a thin white line (Figure 12). Use the Line Tool to draw four lines tracing the boundary of the tenon.

Step 10 Select the Push/Pull Tool. Click on the rectangle you just drew, and push it backward to create the mortise (Figure 13). To make the mortise the proper depth, click on the back edge of the tenon to stop the movement. Deselect the leg component by right-clicking on the screen outside the boundary of the component, and deselect X-Ray from the Face Style Menu. Move the skirt away from the leg and view the finished mortise, as shown in Figure 14.

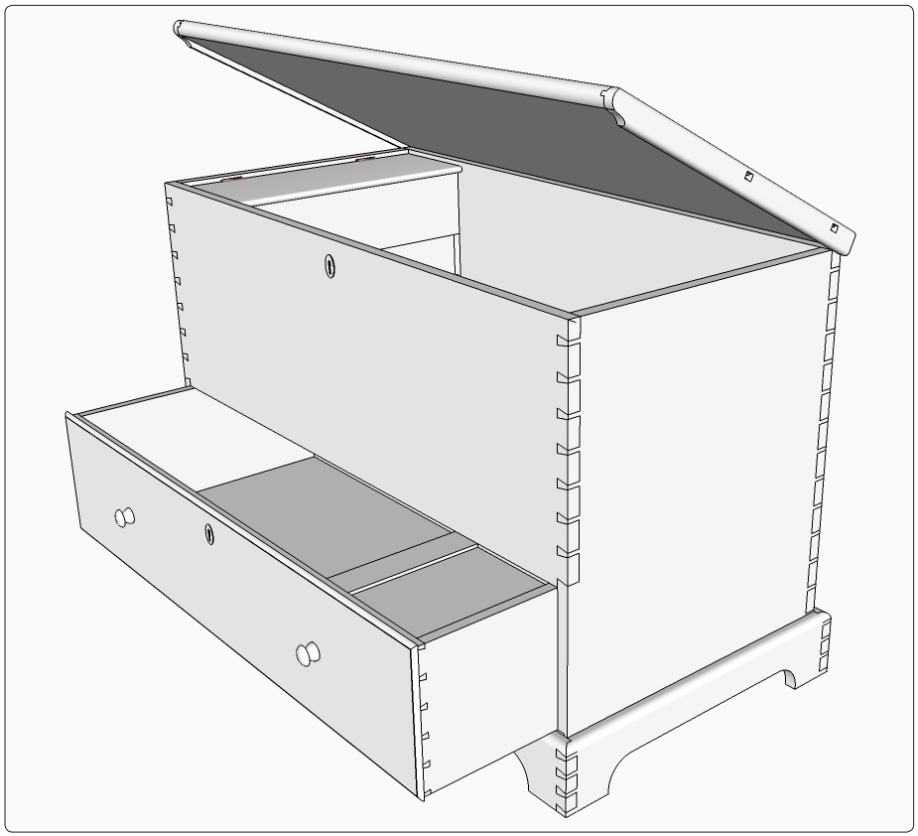


Figure 15. *This Shaker blanket chest makes a good piece for practicing how to make dovetail joints in SketchUp.*

The Dovetail Joint

The Shaker blanket chest shown in Figure 15 uses dovetail joints throughout: in the carcase, the base, the drawer, and the till. I'll show you how to use SketchUp to make the through-dovetails in the carcase. You can use the same procedures for other variations of the dovetail joint.

There are numerous plug-ins for SketchUp that create dovetails automatically, but I don't use them. The ones I've seen limit the options for shape and layout. I think it's better to learn how to render dovetail joints from scratch. That will advance your skills and benefit your overall modeling capability and speed.

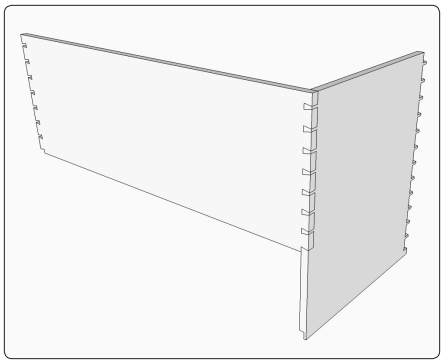


Figure 16. *You will duplicate the dovetails on the carcase, shown in the foreground.*

In this exercise, you'll duplicate the dovetail joint in the front corner of the chest's carcase, as shown in Figure 16. You'll draw pin shapes, which are actually the spaces between the tails. Then you'll use the tails to shape the pins. Figure 17 gives the important dimensions.

Step 1 Create a front component 14 in. wide by 40 in. long by ¾ in. thick, with its face on the red axis. Create a side component 23 in. wide by 19¾ in. long by ¾ in. thick, with its face on the green axis. Connect the two components at their outside corners, as shown in Figure 18.

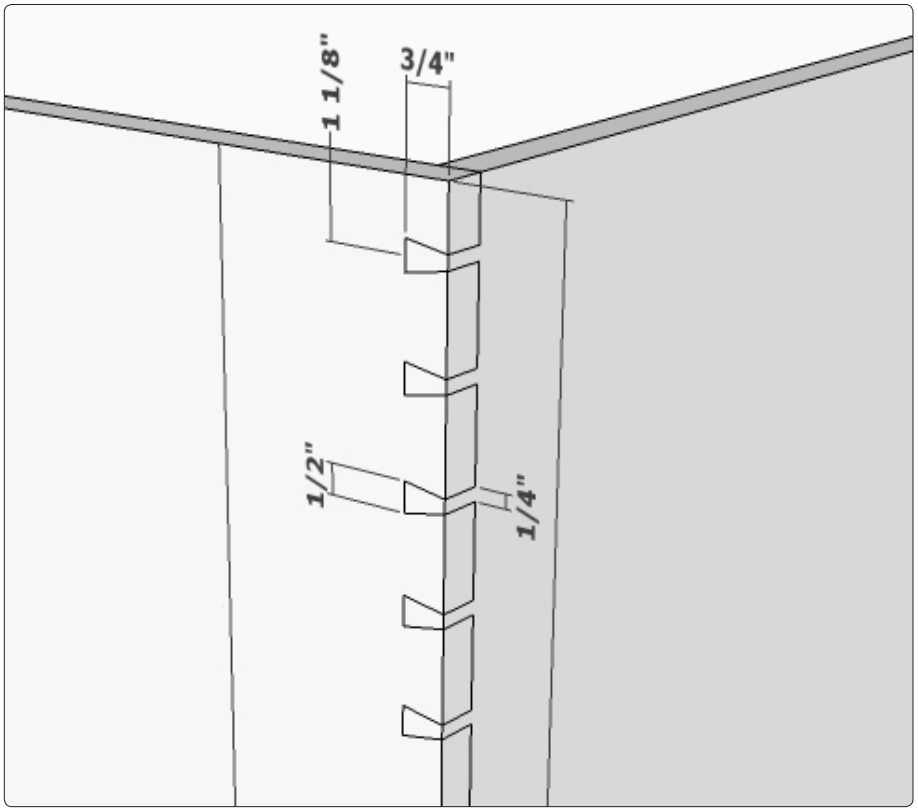


Figure 17. *The key dimensions for the dovetails.*

Step 2 Locate the center of the top and bottom pins. This will help space the pins. Use the Tape Measure Tool to create two guidelines on the front component, one 1⅛ in. down from the top edge and another up ¼ in. from the bottom edge (Figure 18). These mark the midpoint of the top and bottom pins.

Step 3 Use the Line Tool to draw a line along the blue axis between the two guide lines, as shown in Figure 19. Right-click on the line and choose Divide from the pop-up menu. Hover the mouse over the line and watch the number of divisions change as you move along the blue axis. Tap the mouse when you reach the desired number of segments. I stopped at seven, as shown in Figure 20. This gives me eight nodes for locating the pins. (The bottom pin is actually a half-pin.)

Step 4 Use the Tape Measure Tool to place guide lines that outline the pin size. I like to have pin widths that fit my chisel sizes, so I've chosen to make the throat of the pin ¼ in. wide and the wide portion of the pin ½ in. wide. That requires four guide lines in all: two that are ⅛ in. on either side of the midpoint, and two that are ¼ in. on either side of the midpoint. Place these guide lines around the guide line near the top of the front component (Figure 21).

Step 5 Right-click on the front component and choose Edit Component from

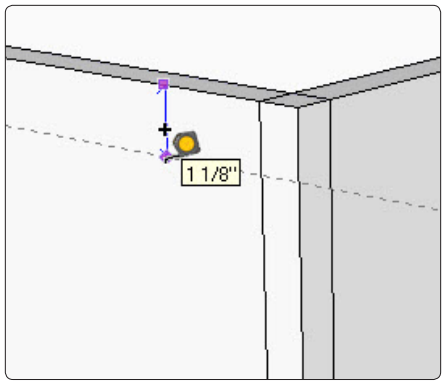


Figure 18. *Connect the two components at their outside corners, so that they overlap. Then draw two guide lines to help you locate the pins and tails.*

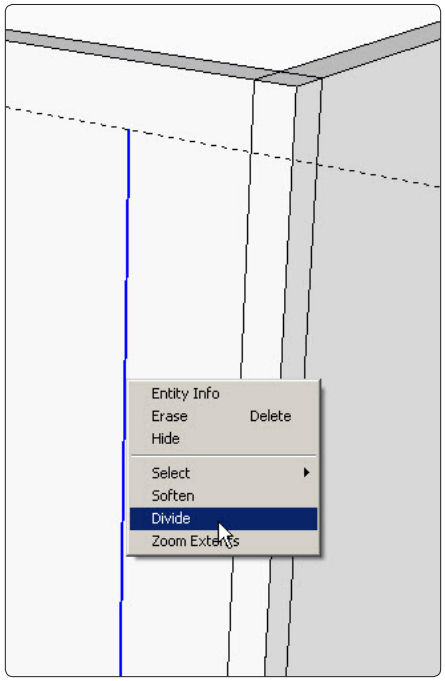


Figure 19. *Draw a line and divide it into segments. You'll use the divisions to place copies of the pin shapes quickly and precisely.*

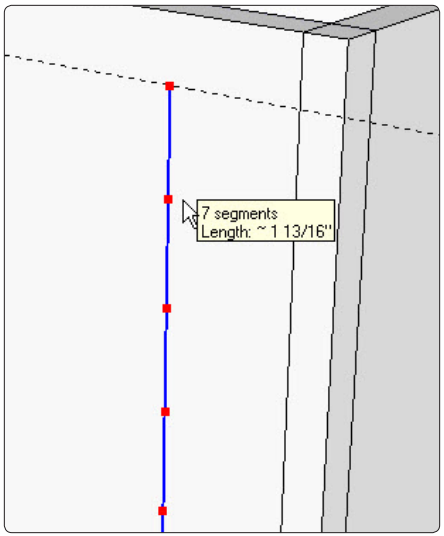


Figure 20. *A pop-up window tells you how many divisions you have selected and the length of each division. You change the number by moving the mouse up and down the line.*

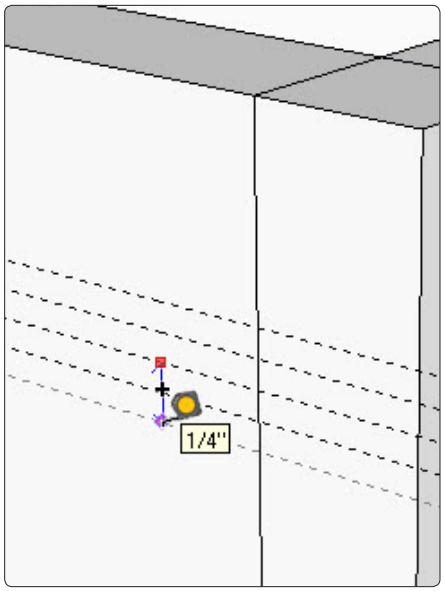


Figure 21. *Place a series of guide lines to define the basic pin shape.*

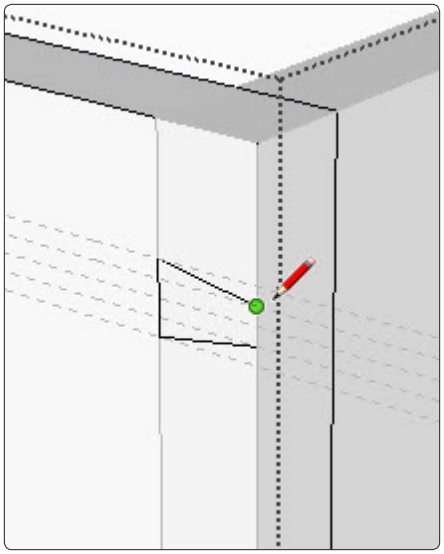


Figure 22. *Use the Line Tool and the guide lines and outline the pin shape.*

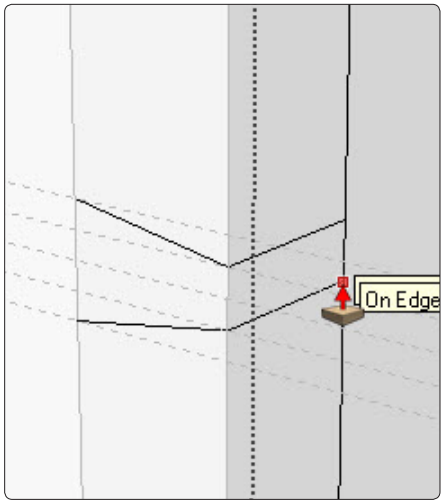


Figure 23. *Use the Push/Pull Tool to push out the pin shape in the front component. Click on the edge of the component to stop the movement.*

Placing Guide Lines with the Protractor Tool

The Protractor Tool is just below the Tape Measure Tool in the vertical toolbar. When you select it, the cursor changes to a circular protractor shape.

To use the tool to place angled guide lines on the front component of the Shaker blanket chest, hover over the face; the protractor will appear green. That's because the front component is on the red–blue axis, so the rotation will occur on the green axis. (If you orbit to the top of the component and hover over it with the Protractor Tool, its color will be blue; that's because the top face is on the red–green axis.)

To place an angled guide line, click the Protractor Tool on the edge of the component, as shown in Figure A. Move the mouse from right to left along the face; be sure the dotted line trailing the cursor is red, indicating that you're on-axis. Click the mouse to begin the rotation. Move the mouse upward, type 9.5, and press the Enter key. This ends the rotation and places a guide line at a 9.5-degree angle. Make a similarly angled guide line at the lower part of the dovetail. Then use the Line Tool to trace over these guide lines.

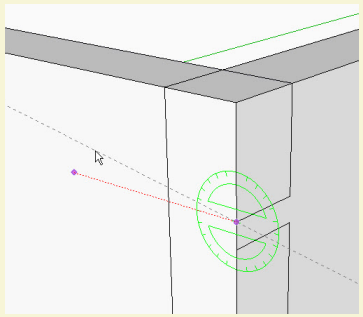


Figure A. *With the Protractor Tool anchored at an intersection of two lines, move the mouse away from the intersection, then move it to rotate the guide line. For a precise measurement, type the number of degrees and press the Enter key.*

Like its real counterpart, the Protractor Tool is useful for measuring angles. Simply click the Protractor Tool on the origin of the angle, click the mouse on one leg of the angle, then click on the other leg of the angle. The value will be displayed in the Measurements Box.

the pop-up menu. Use the Line Tool to draw the outline of the first pin, using the guideline intersections as endpoints (Figure 22).

The angle of this dovetail is about 9.5 degrees, which is a ratio of 1:6. Because I try to work out dovetail sizes that fit my chisels, I'm not aiming for a specific angle. But if you do, use the Protractor Tool to place the guidelines for the dovetail shape. For details, see "Placing Guide Lines with the Protractor Tool," above.

Step 6 Choose the Push/Pull Tool, hover over the pin shape, click the mouse, and push the shape back along the green axis. Click the mouse on the back edge of the

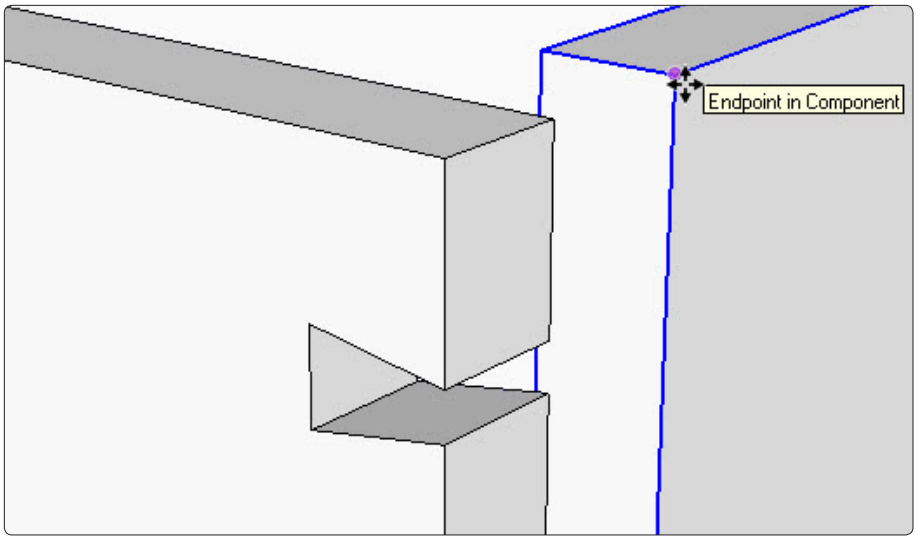


Figure 24. *When you separate the two components, you can see that you've created a space for a pin in the front component.*

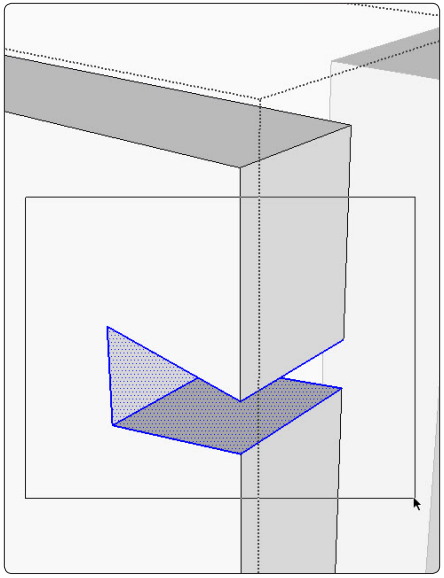


Figure 25. *Carefully draw a left-to-right Selection Box to highlight the parts that define the pin space.*

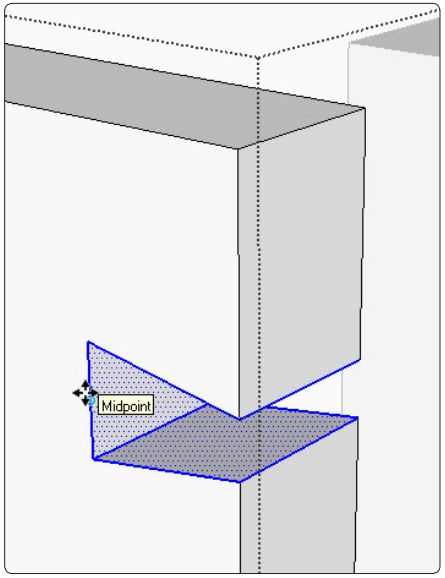


Figure 26. *Use the Move/Copy Tool to grab the selected pin space at the midpoint. SketchUp will tell you when you've found the right spot.*

front component to stop the movement. The process is shown in Figure 23. This step creates an open gap in the front component, which will accept the pin that you will make later on the side component. Go ahead and separate the two components using the Move Tool, as shown in Figure 24. You can see the dovetail-shaped gap that you produced.

Step 7 Now you can copy the pin shape to all the other positions down the edge of the front component. Right-click on the component and choose Edit Component from the pop-up menu. Use the Select Tool to select all of the graphics for the pin by drawing a left-to-right Selection Box around it, as shown in Figure 25. Be sure the box is large enough to cover the graphics on the back face of the pin shape. (Use the Orbit Tool to be sure.) But don't make the box so big that it picks up other edges or faces in the front component.

Choose the Move/Copy Tool and click on the midpoint of the pin shape (Figure 26). Then press the Ctrl key (Option key on the Mac) to make a copy. Begin to move the copy down along the blue axis. Push the Down or Up Arrow key to constrain the move along the blue axis.

Move the mouse over to the divided line. The copied pin shape will stay on-axis. When the mouse reaches a division point in the line, the inference point will change from red to green and a text flag reading "Constrained on Line from Point" will indicate that you've reached a division point (Figure 27). Click the mouse to fix the position of the copied pin shape.

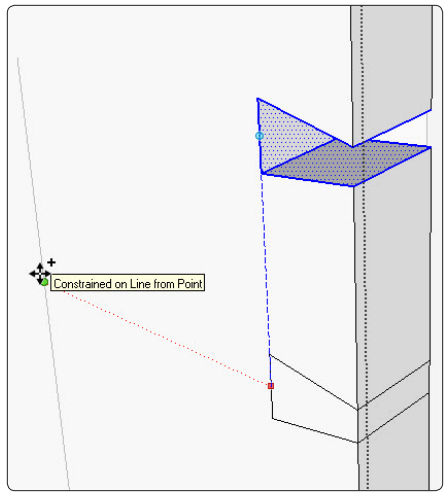


Figure 27. *Copy the pin shape and move it down along the blue axis. Hover the mouse over the divided line until a SketchUp window appears to tell you that you've found a division point. That's where you'll fix the position of the copied shape.*

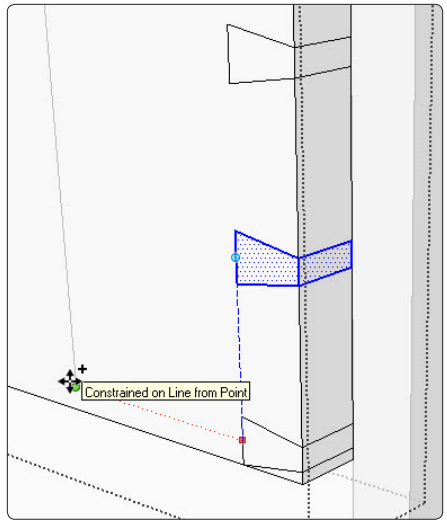


Figure 28. *Place additional copies so that their midpoints fall on the other divisions of the divided line.*

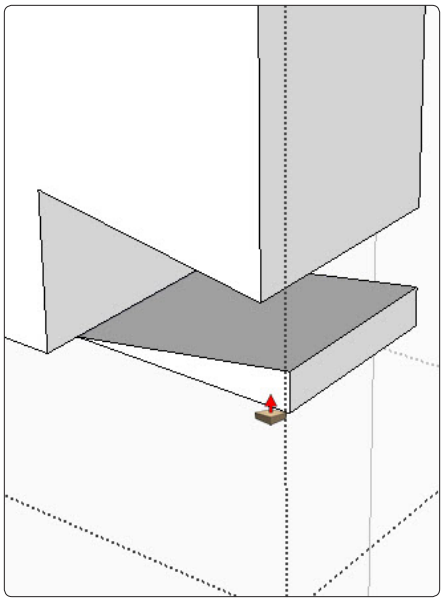


Figure 29. *Push out the waste, including the little sliver at the bottom.*

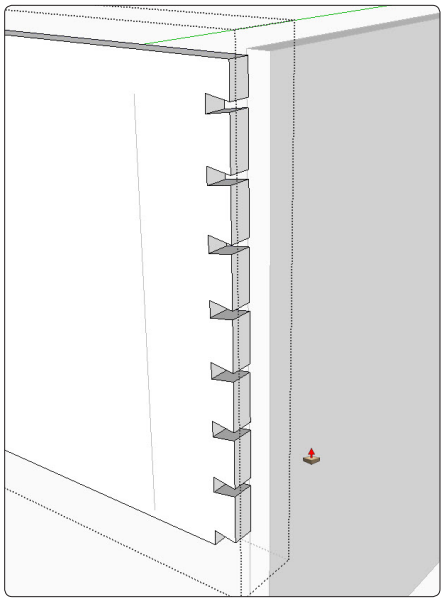


Figure 30. *This is how the completed tails should look on the front component.*

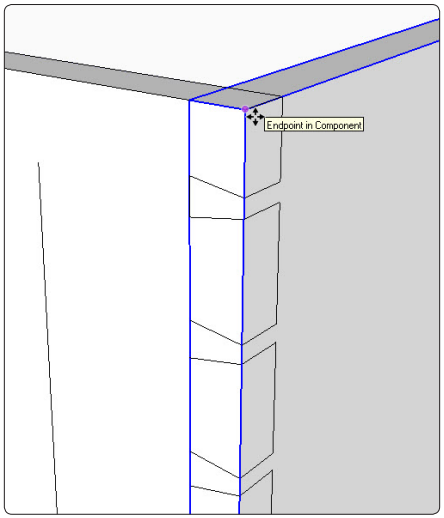


Figure 31. *Use the Move/Copy Tool to reconnect the two components so that you can use the tails to shape the pins.*

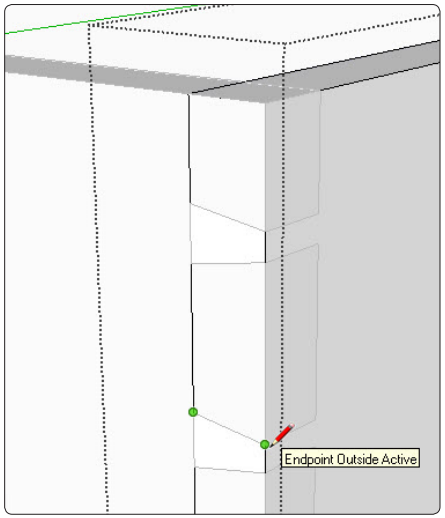


Figure 32. *With the side component selected for editing, use the Line Tool to draw over the pin shapes on the edge of the component.*

Step 8 Continue placing copies at each of the line division points. The final pin placement is made at the endpoint of the divided line, as shown in Figure 28. The bottom pin is a half-pin, which requires some cleanup. Use the Push/Pull Tool to push out the pin shape and the small waste wedge, as shown in Figure 29.

Step 9 Use the Push/Pull Tool to push out waste from the other pin locations. Once you've pushed one and clicked on the back edge, use this shortcut to clear waste from the rest: Double-click with the Push/Pull Tool on the remaining pin locations. You should now have a front component that looks like the one shown in Figure 30.

Step 10 Use the tails in the front component to shape the pins on the side component. With the Move/Copy Tool, join the two components at their top outside corners, as shown in Figure 31.

Step 11 Right-click on the side component and choose Edit Component from the pop-up menu. Use the Line Tool to trace over each angled edge of the pins, as shown in Figure 32.

Step 12 Use the Push/Pull Tool to push out the tail shape. Click on the back edge of the front component to stop the push (Figure 33). Double-click the Push/Pull Tool on each of the remaining tail shapes to remove the waste. Figure 34 shows the final joint after moving the two components apart with the Move/Copy Tool. You can copy and paste the pins to the opposite ends of the respective components, as you did with the tenon earlier in the chapter. Remember to use the Flip Along function to orient the copied pins and tails properly.

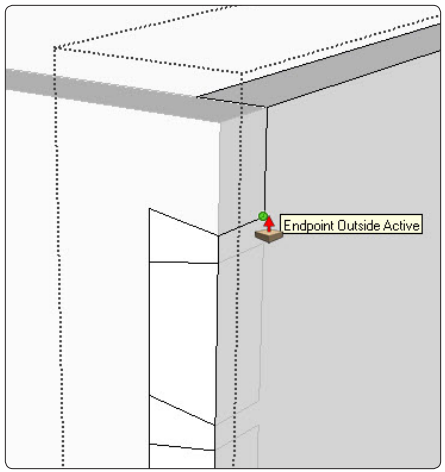


Figure 33. *Use the Push/Pull Tool to push out the tail shape.*

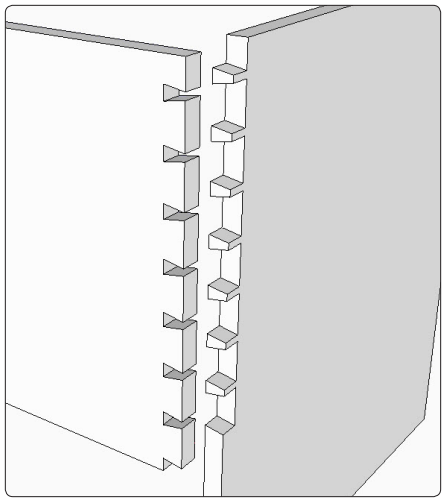


Figure 34. *This is what the finished dovetail joint should look like.*

How to Begin and Develop a Piece of Furniture

Now that we've covered the basic tools and steps in creating a SketchUp design, here's how to put it all together to create a design for a piece of furniture.

This chapter takes you from start to finish in designing the small table shown in the photo at right. It's one of the pieces in the *Furniture Treasury* by Wallace Nutting. In the book, Nutting provides only this cursory description: "Chamfered Posts. Top Gouge Carved. 1700. From Churchill Family. Newington, Connecticut. At Wadsworth Atheneum. George Dudley Seymour." When I first built this, there were no dimensions provided. I guessed at the height, and from that worked out the other dimensions. Since then, I found another reference document provided by the Connecticut Historical Society. That book says the table is 28½ in. high and the top is 28 in. by 20 in. My guesses weren't that far off.

Before we get started, remember that it's important to begin with the proper setup procedure: A default template with appropriate SketchUp settings for woodworking, including units, dimension styles, edge profiles, background, and toolbars.

Figure 1 gives dimensions for the table, and Figure 2 is an exploded view of the components you will be creating. Print those images so you can refer to them as needed as you build your own SketchUp design.

Roughing out the Legs

Step 1 Create one rough leg, using the Line and Push/Pull Tools (Figure 3). To generate accurate sizes, type actual lengths, which appear in the Measurements Box. Make the shape a component and name it Leg. You'll add the chamfers and mortises later.

Step 2 Copy the leg component and place it in position. Use the Tape Measure Tool to place a guide line to locate the right front leg. Use the Move/Copy Tool to copy the left leg and move it along the red axis until it connects with the guide line. (To stay on the red axis, push the right arrow key or hold the Shift key). Right-click on the copy of the leg component and choose Flip Along Red Axis from the pop-up menus to mirror the copy (Figure 4).

Step 3 Use the Tape Measure Tool to place another guide line along the green axis to locate the rear legs. Select and copy the two front legs to create the rear legs. Use the Flip Along function along the green axis to mirror the rear legs (Figure 5).

I've made several copies of this 18th-century chamfered-post table working from detailed plans I created in SketchUp. The version shown here is painted sugar pine.

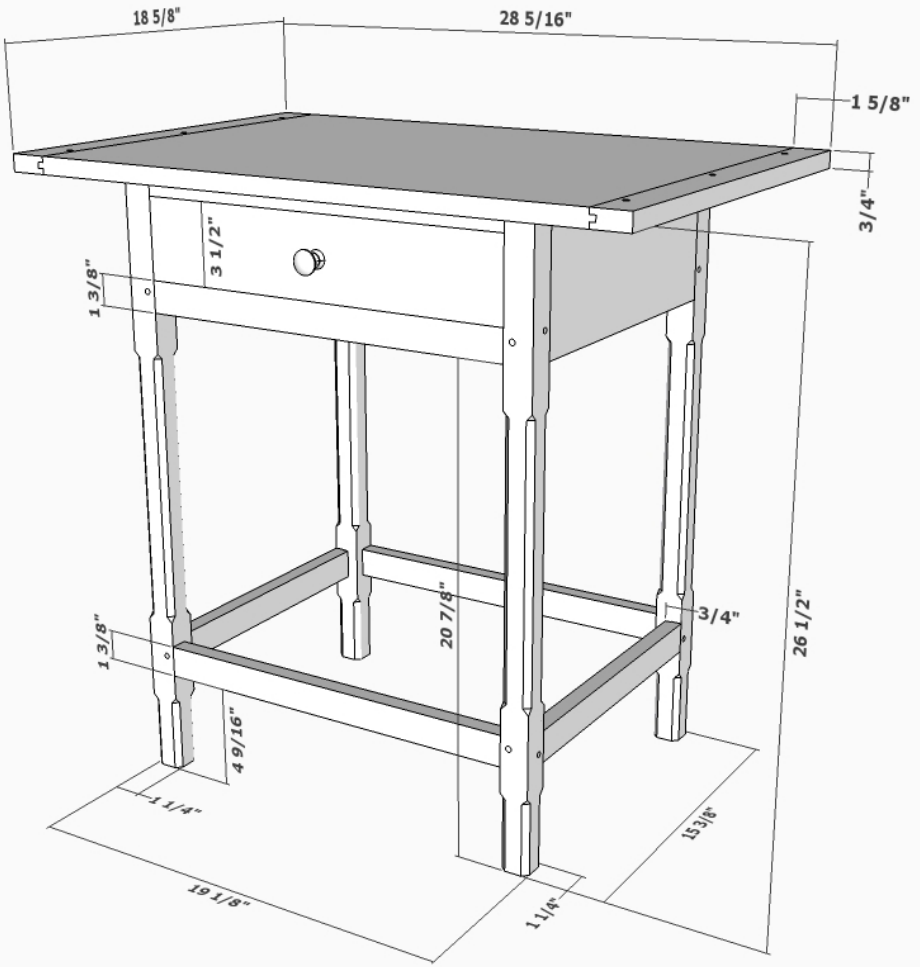


Figure 1. *Overall dimensions for the chamfered-post table.*

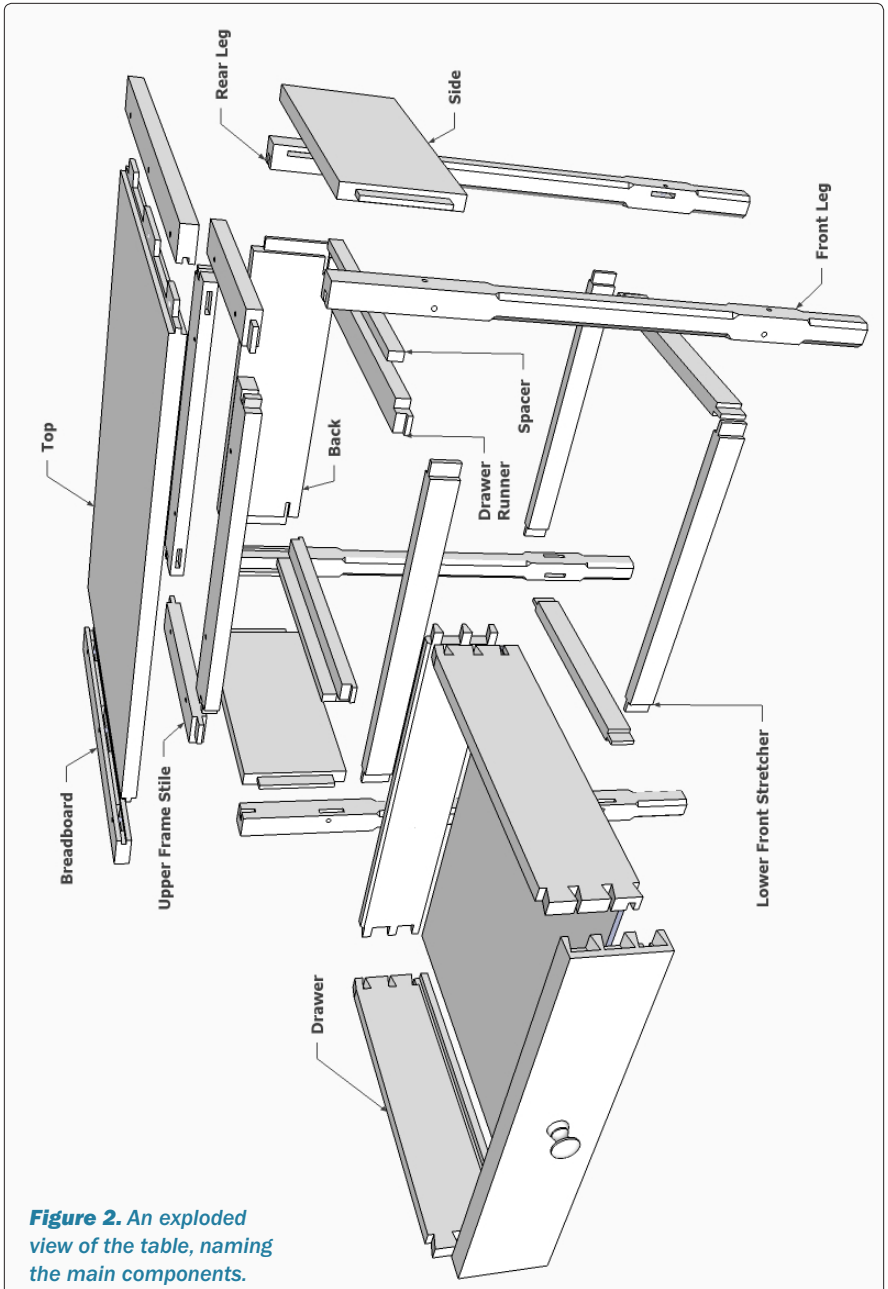


Figure 2. *An exploded view of the table, naming the main components.*

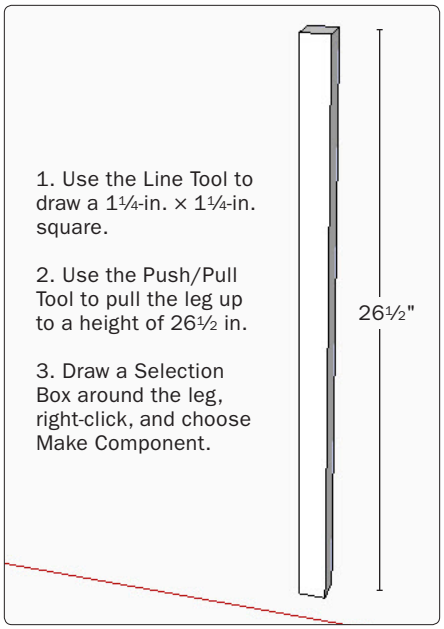


Figure 3. *Rough out the leg component.*

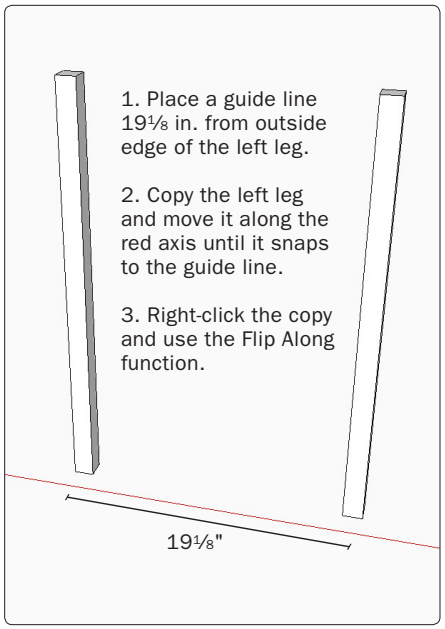


Figure 4. *Copy the leg component and place it in position.*

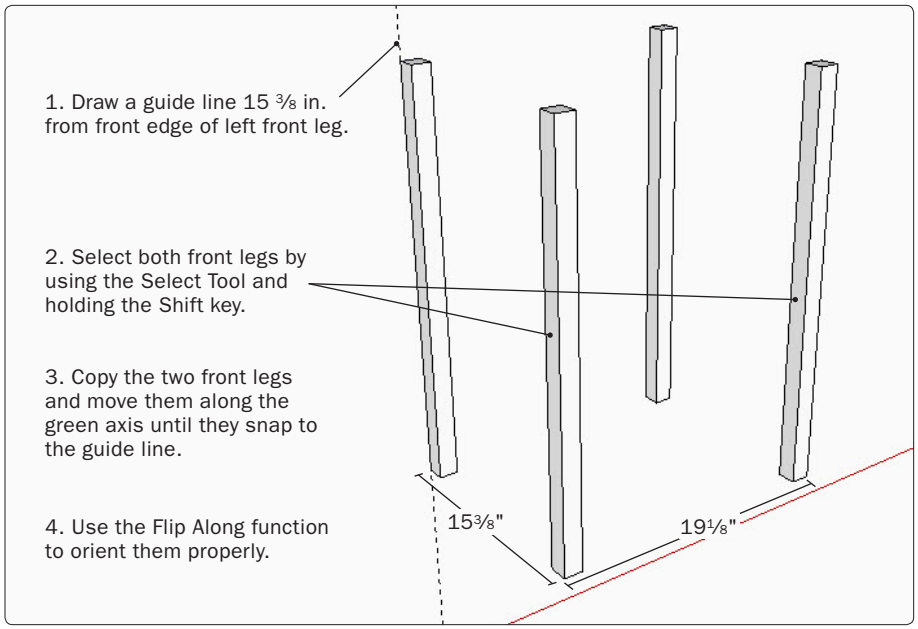


Figure 5. *Copy the front legs to make the rear legs.*

Rough Out the Stretcher Components

Step 4 Use the Tape Measure Tool to draw a guide line 4⁹⁄₁₆ in. from the bottom of a leg to locate the bottom of the lower stretcher. Beginning at that point, use the Line Tool to draw the lower front stretcher in position between the legs. Draw the front face of the stretcher, then use the Push/Pull Tool to give it the proper thickness. (Do not select and edit the leg component while making the stretcher.) Draw a left-to-right Selection Box around the stretcher, right-click, choose Make Component from the pop-up menu, and name the component. Follow the same steps to draw in one side stretcher (Figure 6).

Step 5 Use the Move/Copy Tool to copy the stretchers so that all four legs are connected. After you have moved each stretcher, use the Flip Along function to mirror it. You should have four stretchers in position, as shown in Figure 7.

Rough Out the Upper Front Stretcher, Side, and Back Components

Step 6 Use the Tape Measure Tool to place a guide line 5⅝ in. from the top of the leg to locate the upper components. To make the upper front stretcher, copy the lower front stretcher and move it along the blue axis until the lower corners meet the guideline you just drew. Right-click on this copy and choose Explode from the pop-up menu. Right-

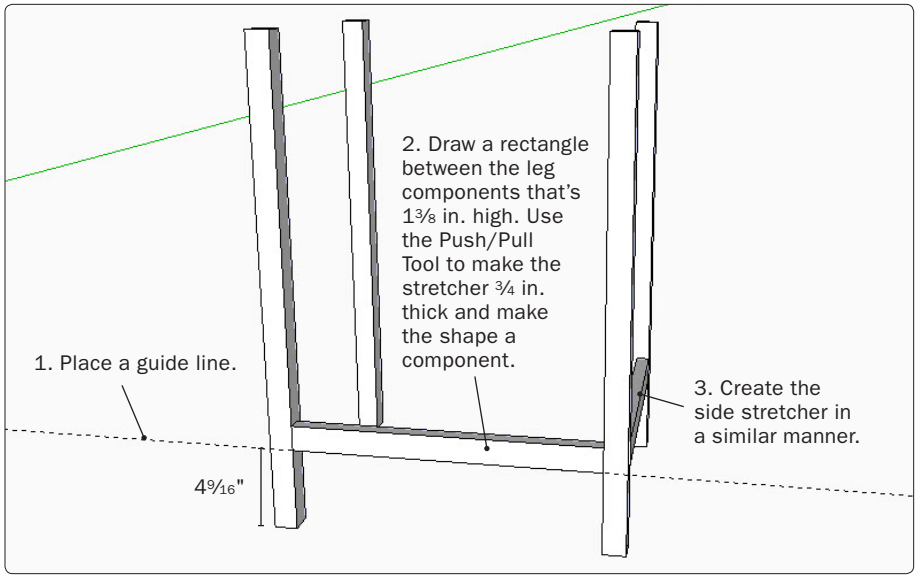


Figure 6. *Rough out the lower stretchers.*

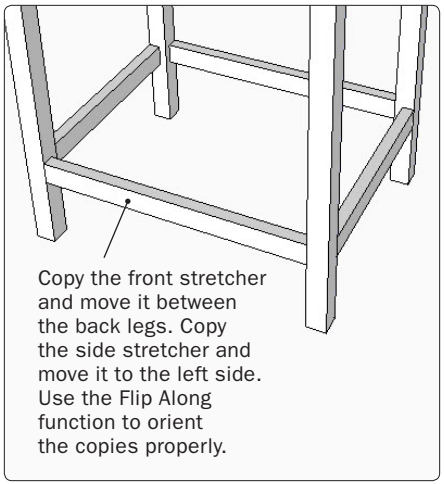


Figure 7. *Copy the lower stretchers.*

click again, select Make Component, and name the component.

Draw the side and back components the same way you did the lower stretchers: Use the Line Tool to draw one face, make it a component, then use the Push/Pull Tool to give it the proper thickness. Note that the top of the back piece is ¾ in. below the top of the rear legs. This allows space for the upper frame rail to be added later. As you did with the lower stretchers, use the Move/Copy Tool to copy the side component. Use the Flip Along function when you have moved the copy into position (Figure 8).

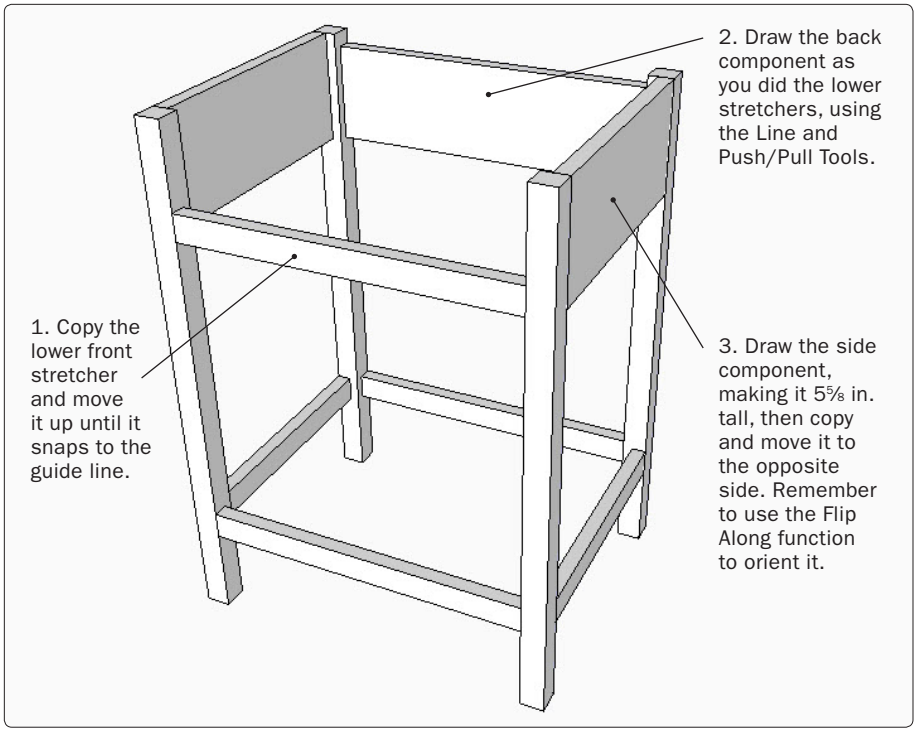


Figure 8. *Create the upper frame components.*

Create the Leg Chamfers

Step 7 Make a temporary copy of a leg component and move it slightly away from the model. Use the Tape Measure Tool to place guide lines over adjacent faces of the copy, as shown in Figure 9. These will locate the chamfer boundaries. Select the leg component, right-click, and choose Edit Component from the pop-up menu. Use the Line Tool to draw lines over the guide lines to define the chamfer boundary.

Step 8 Create the termination point of the chamfer by drawing angled lines up to the point where the guide line intersects the edge of the leg component, as shown in Figure 10. Then in the View Menu, switch the face style to X-Ray View to draw the hidden lines that form the base of the chamfer.

Step 9 Follow the same steps to create the upper chamfer, using the dimensions shown in Figure 11.

Step 10 Copy the chamfers to the other three corners of the leg component. In the Camera Menu, select Top View and Parallel Projection. In the View Menu, switch the face style to X-Ray View. This way, looking down on the top of the post, you will see the chamfers you just created in one corner. Draw guide lines, as shown in Figure 12, to find the center of the leg. Select the leg component, right-click, and choose Edit Component from the pop-up menu. Use the Select Tool to draw a left-to-right Selection Box around the chamfers (this will

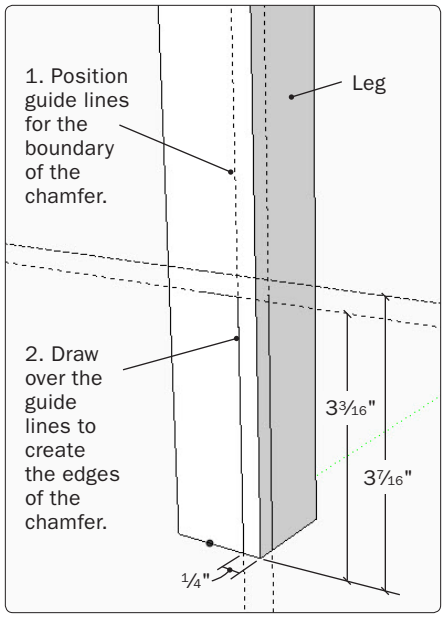


Figure 9. *Zoom in close to the bottom of the leg and begin drawing the chamfer.*

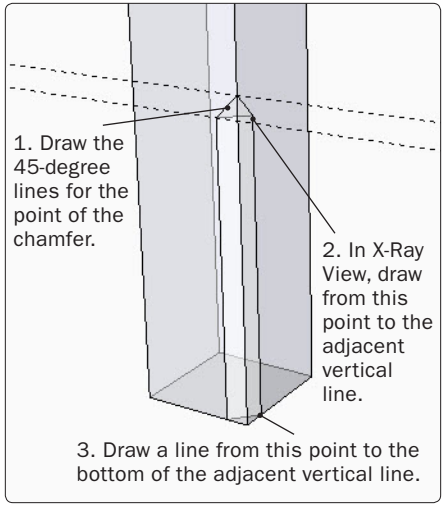


Figure 10. *Draw the angled part of the chamfer, then switch to X-Ray View to draw rest of this element.*

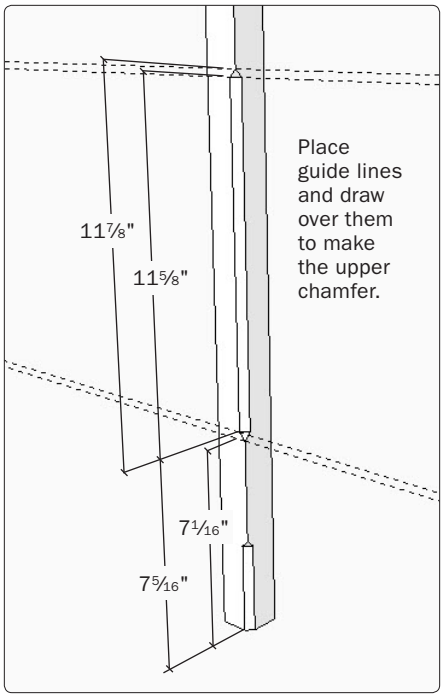


Figure 11. *Use the dimensions shown to make the upper chamfer. Follow the same steps you did for the lower chamfer.*

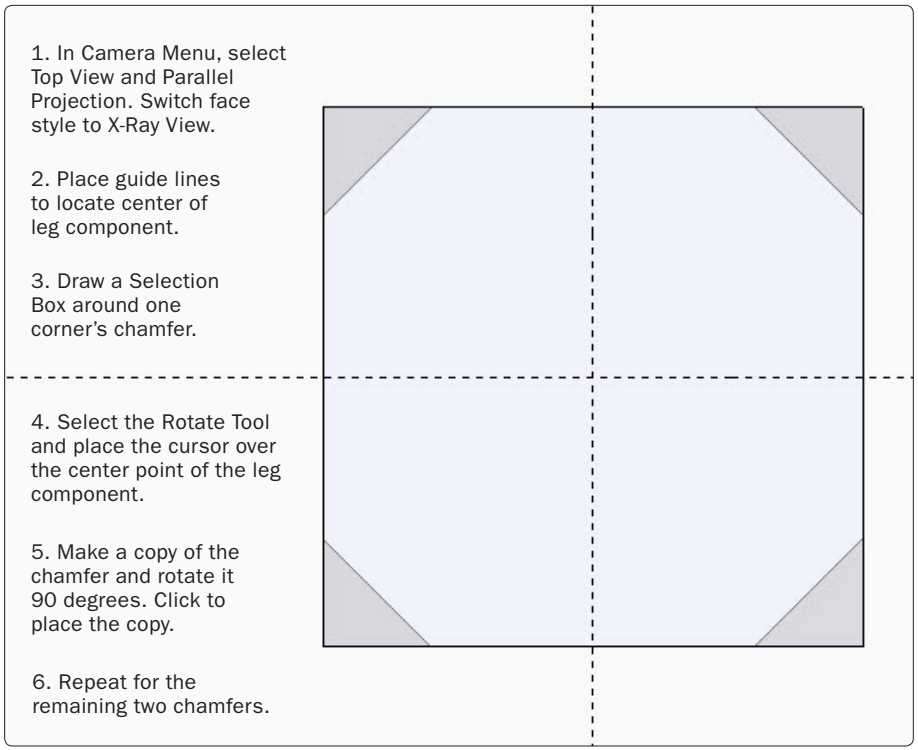


Figure 12. *To copy the chamfers, work in X-Ray View and from the top of the leg component.*

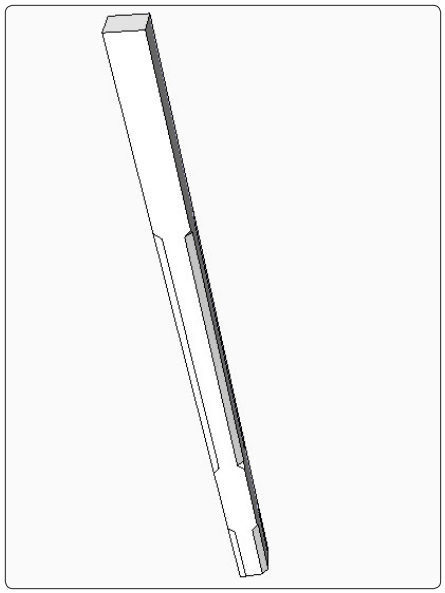


Figure 13. *Delete waste lines to complete the chamfers.*

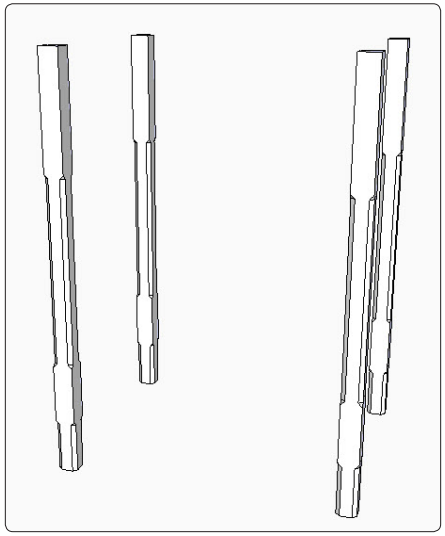


Figure 14. *Because SketchUp automatically updates all copies of a component, all four legs now have identical chamfers.*

select both the upper and the lower chamfers). Choose the Rotate Tool and place the cursor in the center of the square, where the guide lines intersect. Push the Ctrl key (Option key on the Mac) to copy the chamfers, rotate the copy 90 degrees, and click to place the chamfers on the corner. Repeat to copy the chamfers onto the remaining corners.

Step 11 Use the Eraser Tool to delete the waste lines around the copied chamfers, finishing their placement (Figure 13). Because you have added chamfers to this one leg component, all copies of the leg now have the chamfers (Figure 14). When you have completed the chamfers, delete the temporary copy of the leg component.

Add Tenons to the Stretchers, Sides, and Back

Step 12 The tenons on the lower stretchers are the full height of those components. Make a temporary copy of the stretcher and move it slightly away from the rest of the model. Draw guide lines on the end of the stretcher copy, as shown in Figure 15, to help lay out the tenon. Select the stretcher, right-click, and choose Edit Component from the pop-up menu. Use the Line Tool to draw over the guide lines, defining the tenon.

Step 13 Use the Push/Pull Tool to make the tenon the proper length, as shown in Figure 16.

Step 14 Use the procedure described in Chapter 8 to copy the tenon and place it on the other end of the stretcher; Figure 17 summarizes the steps. The top and bottom face will be missing on the copied tenon. Fix that by using the Line

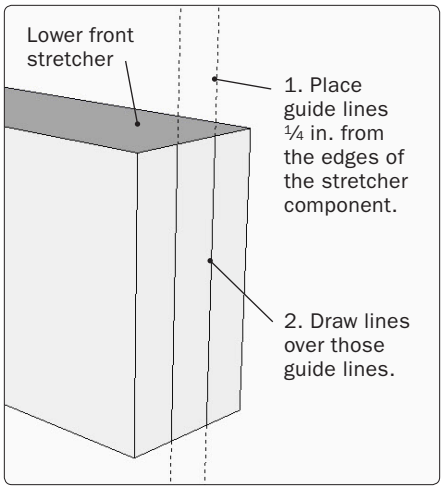


Figure 15. *The bottom stretchers have tenons that are the full height of the component. Place guide lines and draw over them to begin shaping the tenons.*

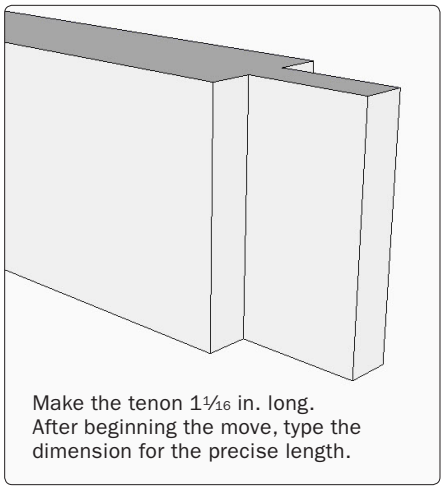


Figure 16. *Use the Push/Pull Tool to complete the tenon.*

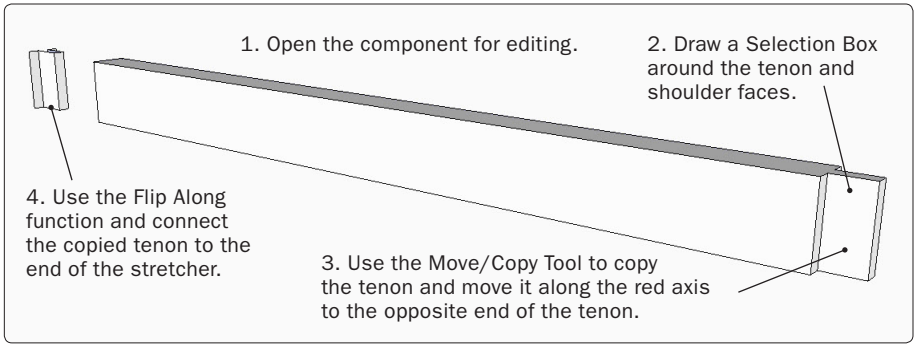


Figure 17. *Copy the tenon and move it to the opposite end of the stretcher.*

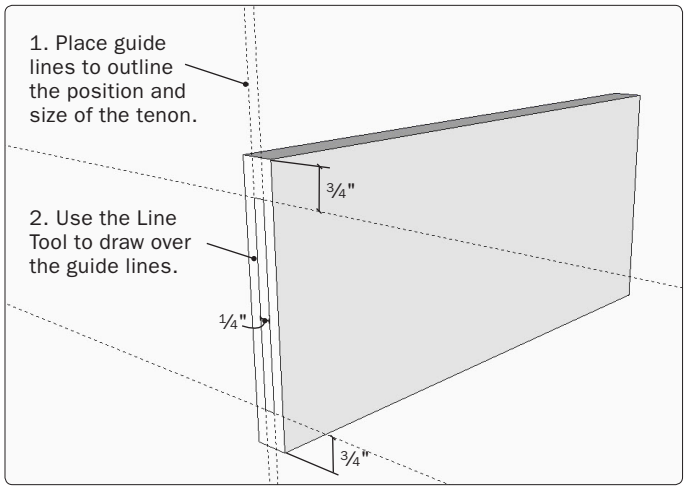


Figure 18. *Tenons on the side components have shoulders on all four sides.*

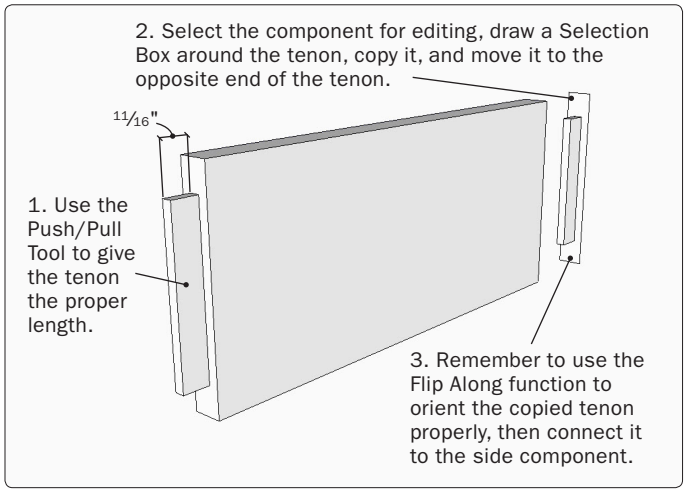


Figure 19. *Finish the tenons on the side components the same way you did others.*

Tool to draw over the missing faces and fill them in. Then delete the extra line that shows up on the top and bottom face at the base of the tenon.

Step 15 Repeat Steps 12 through 14 to add tenons to the lower side stretchers and the upper front stretcher.

Step 16 The tenons on the side components are created in a similar manner as those for the lower stretchers. These tenons have shoulders on all four sides, however. Use the Tape Measure Tool to draw guide lines to help lay out the tenon, following the dimensions shown in Figure 18. Select the side component for editing and use the Line Tool to draw over the guide lines to define the tenon. Then use the Push/Pull Tool to give the tenon the proper length. Type the dimension to set the length precisely.

Step 17 As you did with the lower stretchers, copy the tenon, move it to the other end of the side component, and use the Flip Along function to mirror the tenon. Fix the missing top and bottom faces, as you did in Step 12 (Figure 19).

Step 18 Repeat Steps 16 and 17 to add tenons to the back component, using the same shoulder dimension of ¾ in. Once

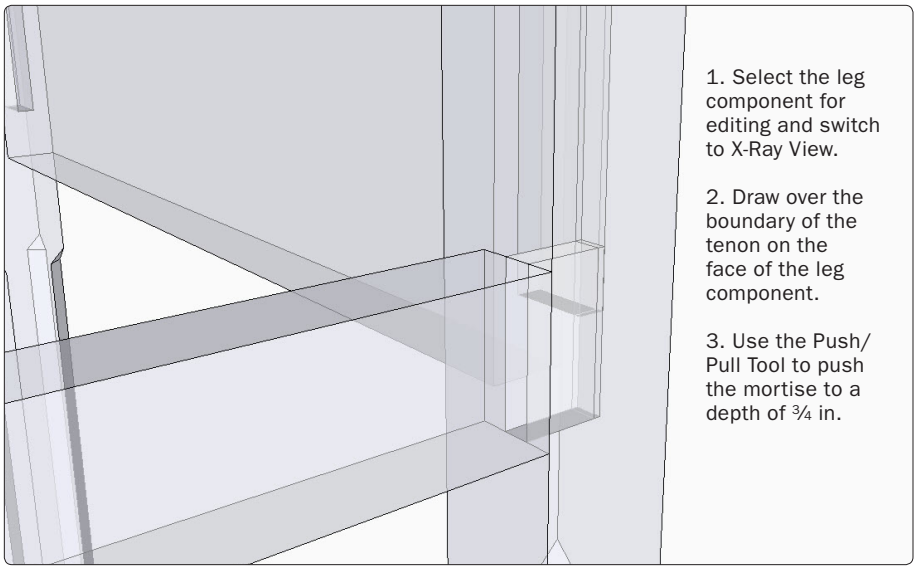


Figure 20. *Use the tenons on the stretchers as guides to shape the mortises in the legs.*

you have drawn the tenons, delete all the temporary copies of the components.

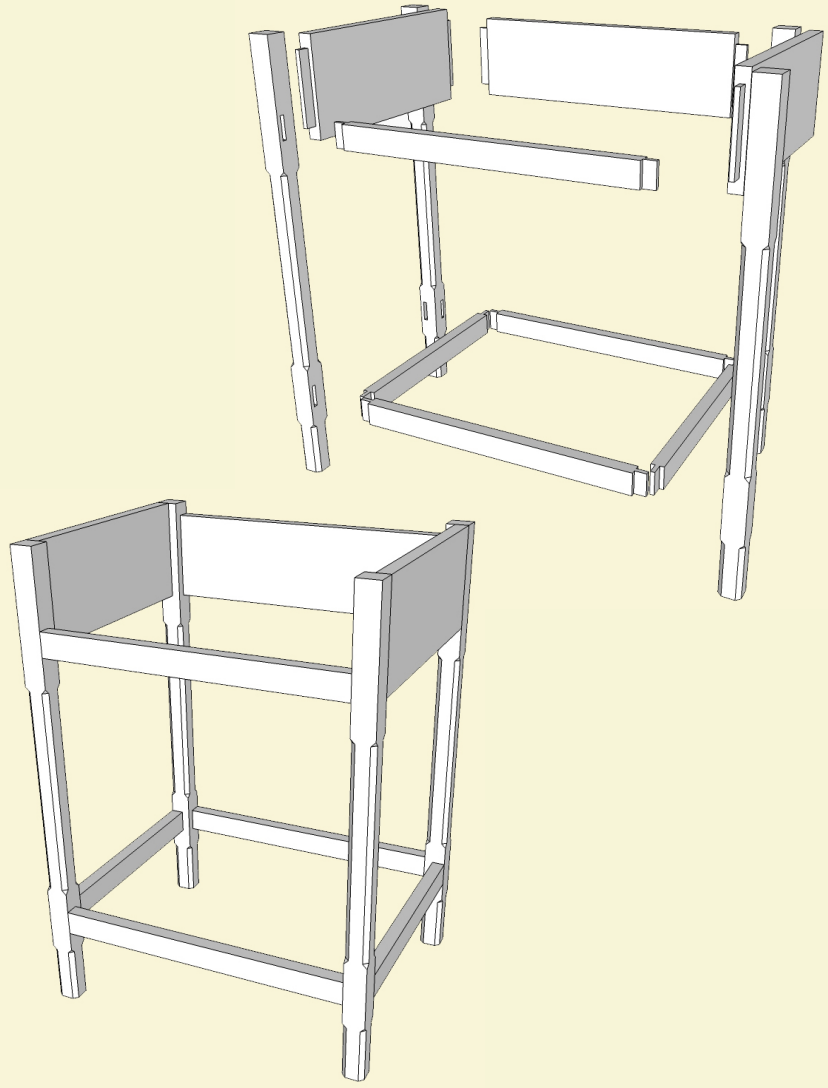
Create the Leg Mortises

Step 19 Use the procedure described in Chapter 8 to create the mortises by using the stretcher tenons as a guide. In the View Menu, change the face style to X-Ray View. You will see the tenon as it enters the leg component. Select the leg component for editing. Use the Line Tool to trace over the rectangle shape of the tenon where it enters the face of the leg. You may have to use the Zoom and Orbit tools to get a good view of the tenon. Choose the Push/Pull Tool and hover over the rectangular face you just created; this will highlight it with a pattern of dots. Push the mortise depth to ¾ in.; click on the end of the tenon to end the movement (Figure 20). Repeat for the remaining mortises in the lower side stretcher, the upper front stretcher, and the side components.

Step 20 The rear legs are not identical to the front legs because the tenons in the back are different from those in the front stretcher. So before you create the mortises for the back piece, you need to make the rear legs a unique component. Do that by right-clicking on a rear leg component and selecting Explode from the pop-up menu. Right-click again and choose Make Component from the pop-up menu. Give the rear leg component a unique name. Once you've done that, delete the other rear leg and replace it with a copy of the new component, suitably flipped along the axis. Then repeat the procedures in Step 19 to add mortises to the rear legs.

Status Report

Here are assembled and exploded views of the table up to this point in its design development. It's about halfway done, with the main structure and joint details completed. The remaining work includes the drawer and its runners, the upper frame, and the top.



Add the Drawer Runners

Step 21 The drawer runners have tenons that fit into mortises in the front stretcher and the back components. The top of the runner is flush with the top face of the front stretcher. Use the Line Tool to draw the runner's top face (1½ in. wide) within the assembled structure, make the face a component, and then use the Push/Pull Tool to give it the proper thickness, as shown in Figure 21. Copy the runner and use the Flip Along function to create its mate.

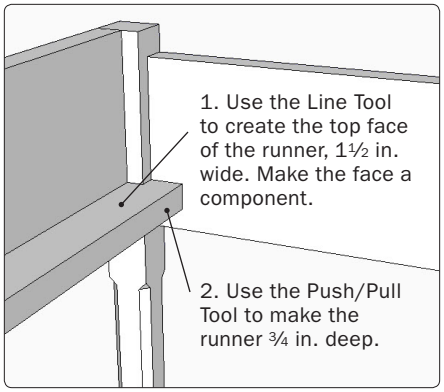


Figure 21. *Rough out the drawer runner in place between other components.*

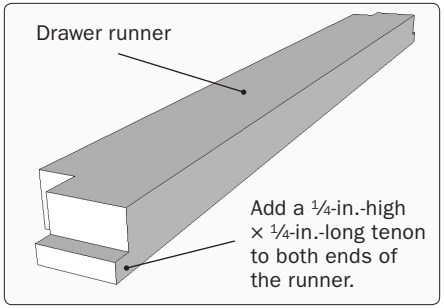


Figure 22. *Work on a temporary copy to add the tenons to the drawer runner.*

Step 22 Create a temporary copy of the drawer runner and move it a short distance from the assembled table structure. It's much easier to add the tenons to the ends of the runners if you work on a copy separated from the assembled table. Place a guide line ¼ in. above the bottom edge of the runner. Right-click on the runner, choose Edit Component from the pop-up menu, and trace a line over the guide line for the top edge of the tenon. Use the Push/Pull Tool to make a ¼-in.-long tenon. Repeat those steps to create the tenon on the other end of the runner (Figure 22). After you complete the tenons, delete the temporary copy.

Create Mortises for the Drawer Runner Tenons

Step 23 Use the runner tenon to create the corresponding mortises in the back and upper front stretcher, just as you did when you made the mortises in the legs. In the View Menu, set the face style to X-Ray View. Right-click on the back component and choose Edit Component from the pop-up menu. Use the Line Tool to trace over the rectangular boundary of the runner tenon as it intersects with the face of the back piece. Use the Orbit and Zoom tools as needed to get a clear view of the joint. Use the Push/Pull Tool to create the ¼-in.-deep mortise (Figure 23). Repeat this process to create the mortise in the upper front stretcher. Figures 24 and 25 show the completed mortises. Repeat the procedure to draw mortises at the opposite end of the back and upper front stretcher.

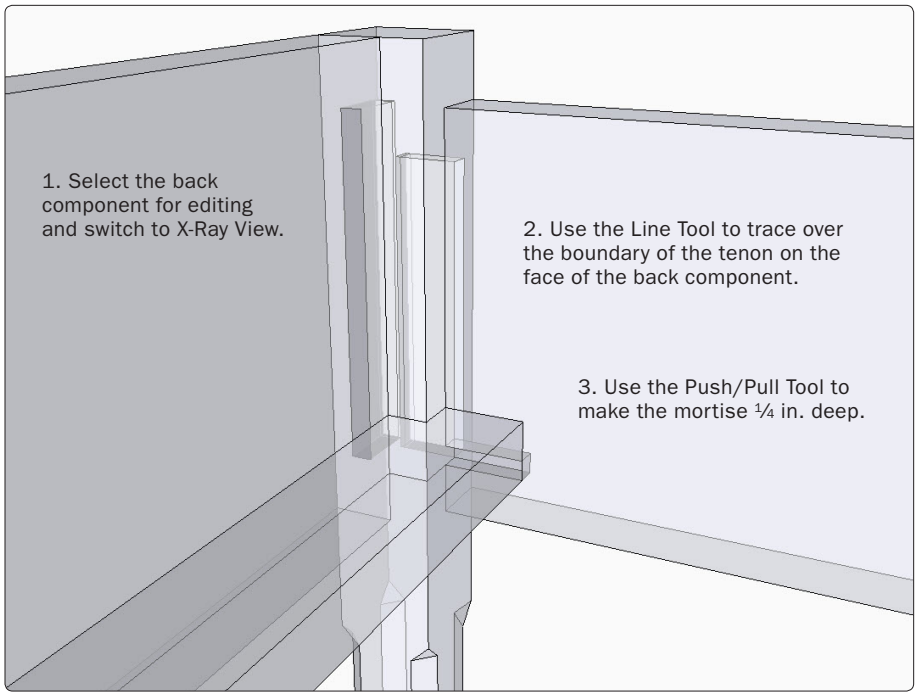


Figure 23. *Make the first mortise for the drawer runner.*

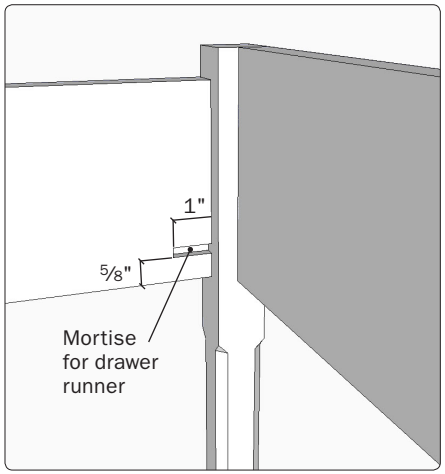


Figure 24. *The completed mortise in the back component.*

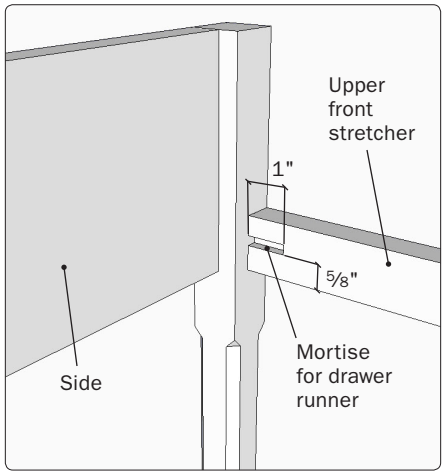


Figure 25. *The completed mortise in the front stretcher.*

Create the Upper Frame Components

The four upper frame components are joined together with mortise-and-tenon joints and are dovetailed into the top of the legs. Figure 26 shows an exploded view, and Figure 27 gives the necessary measurements for the dovetail joint. The next steps show how to create the components, joints, and the dovetail socket in the legs. Finally, I'll show how to render the elongated holes in the upper frame to hold the top and allow for seasonal wood movement. The procedures are not that different from those you would use to create these parts and joints in the shop.

Step 24 Use the Tape Measure Tool to place guide lines defining the front frame rail, including the shape of the dovetail at each end. Use the Line Tool to trace over the guide lines to create the top face of the rail. Make the rail a component and use the Push/Pull Tool to give it the proper thickness (Figure 28).

Step 25 The back frame rail is identical to the front rail, so all you have to do is copy the front rail and move it along the green axis to its proper position. Right-click on the copy and choose Flip Along Green Axis from the pop-up menu to orient this component properly (Figure 29).

Step 26 Make the dovetail socket in the top of the legs. Right-click on one of the front leg components and choose Edit Component from the pop-up menu. Use the Line Tool to trace over the dovetail

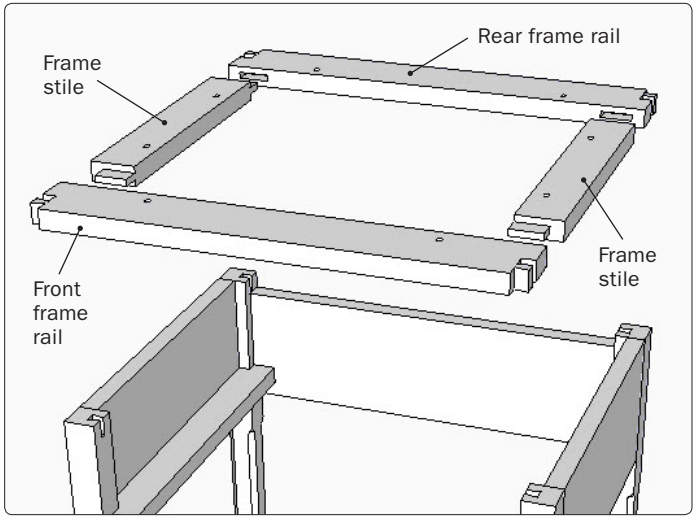


Figure 26. *An exploded view of the upper frame components.*

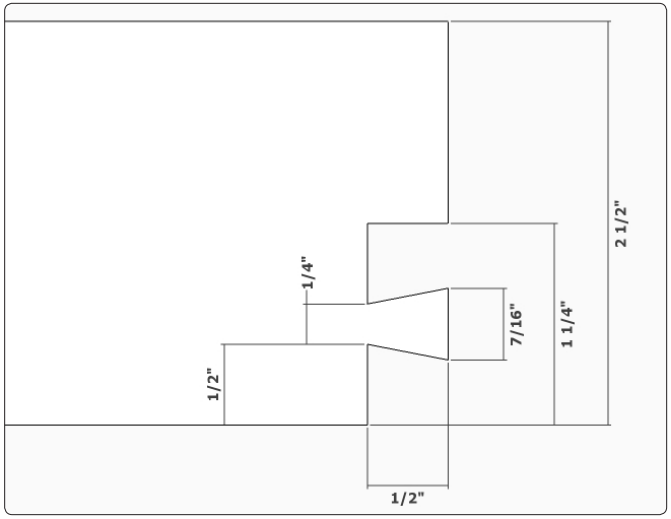


Figure 27. *Dimensions for the dovetail in the front and rear frame rails.*

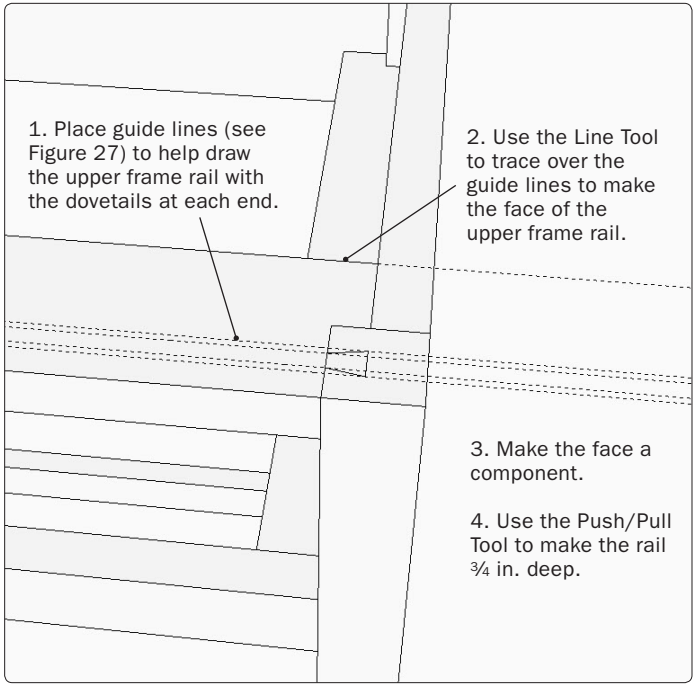


Figure 28. *Draw the front frame rail.*

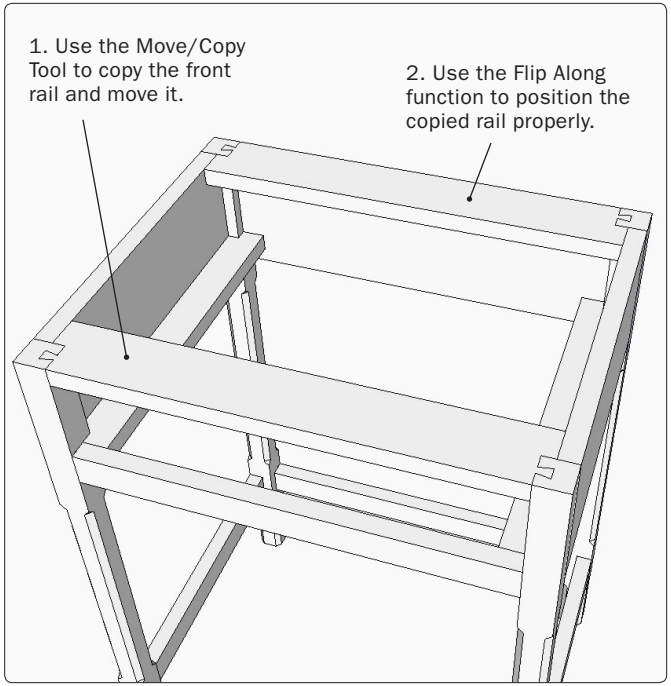


Figure 29. *Copy the front rail to make the rear rail.*

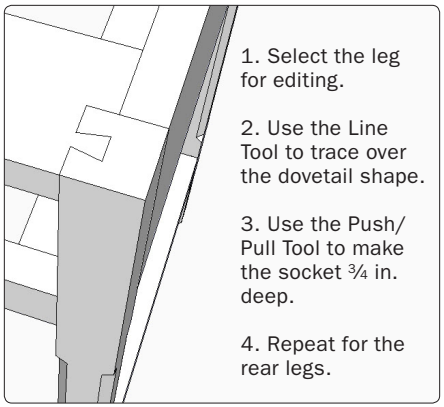


Figure 30. *Make the dovetail socket similar to the way you make mortises.*

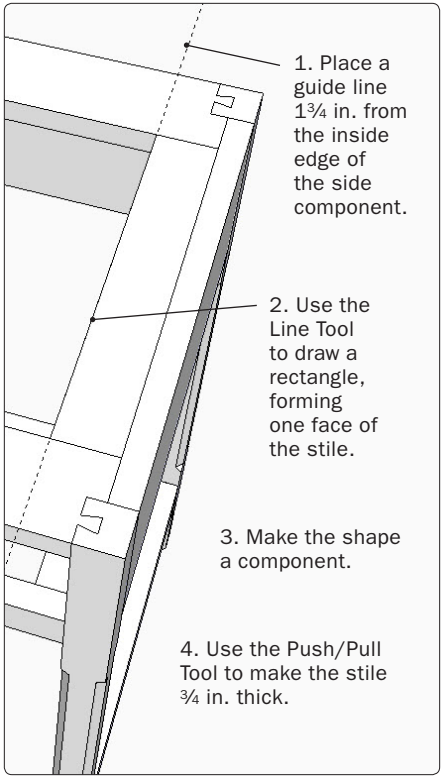


Figure 31. *Make the frame stile.*

shape in the front frame rail. Use the Push/Pull Tool to make the socket the proper depth. Repeat those steps on one rear leg for the remaining pair of dovetail sockets (Figure 30).

Step 27 Create the frame stile by using the Tape Measure Tool to place a guide line for its width. Use the Line Tool to draw a rectangle for the top face of the stile. Make that shape a component. Double-click on the component and use the Push/Pull Tool to make it the proper thickness (Figure 31).

Step 28 Create a temporary copy of the stile and move it slightly away from the table assembly. To make the stile tenons, place guidelines on one end to outline the shape and location. Figure 32 shows the tenon's length and width; it is ¼ in. thick, centered on the stile thickness, as shown in Figure 33. Select the copy of the stile component for editing. Trace over the guidelines with the Line Tool and use the Push/Pull Tool to give the tenon the proper length. Copy the tenon, use the Flip Along function, and connect the tenon to the opposite end of the stile. After creating the tenons on this copy, delete it.

Step 29 Use the Move/Copy Tool to copy the stile to the other side of the frame, as you have with other components. Select the Flip Along Red Axis command to orient it properly. Now, as you did with other components, use the tenons in the stiles to create the mortises in the rails.

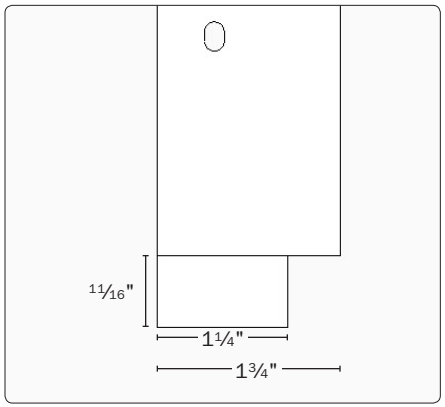


Figure 32. *Dimensions for the tenons on the frame stiles.*

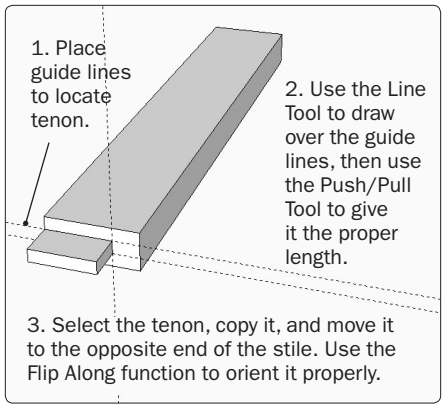


Figure 33. *Create the tenons on the frame stile.*

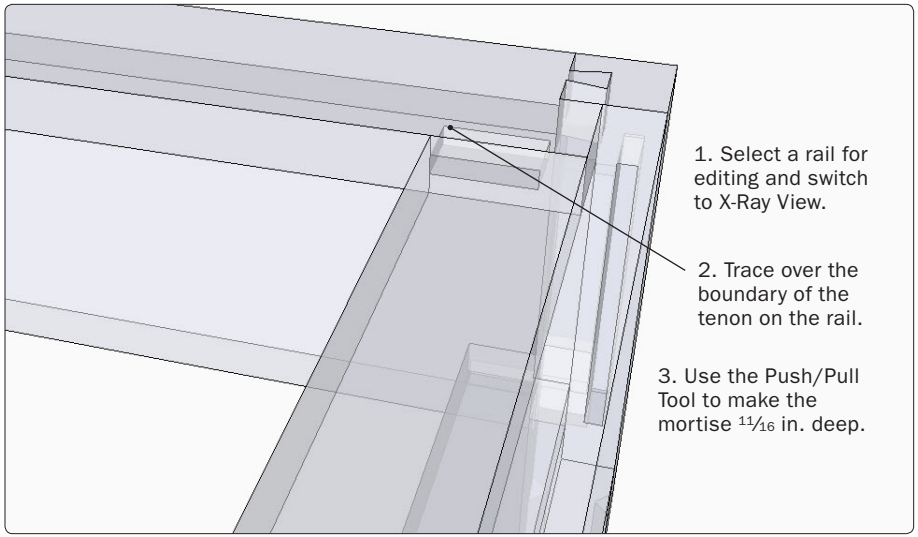


Figure 34. *Complete the top frame construction by creating mortises in the front and rear rail components.*

In the View Menu, set the face view to X-Ray View. Select the rail component for editing. Trace over the shape of the tenon where it intersects with the face of the rail. Use the Push/Pull Tool to give the mortise the proper depth (Figure 34). When you have finished, change the Face View back to Normal.

Step 30 Draw elongated holes in the top frame components for the screws that hold the top in place and allow for seasonal wood movement. Place guide lines

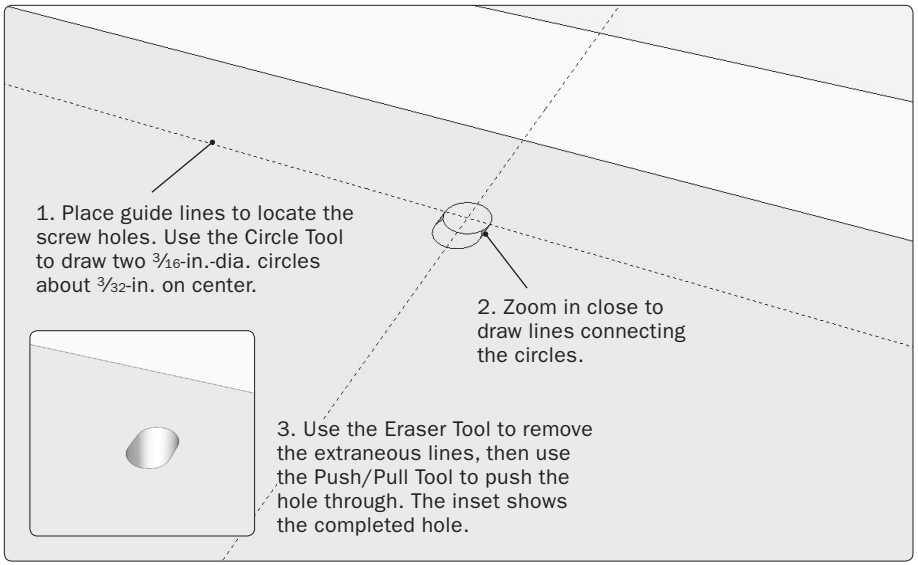


Figure 35. *Creating elongated screw slots mimics actual shop procedures.*

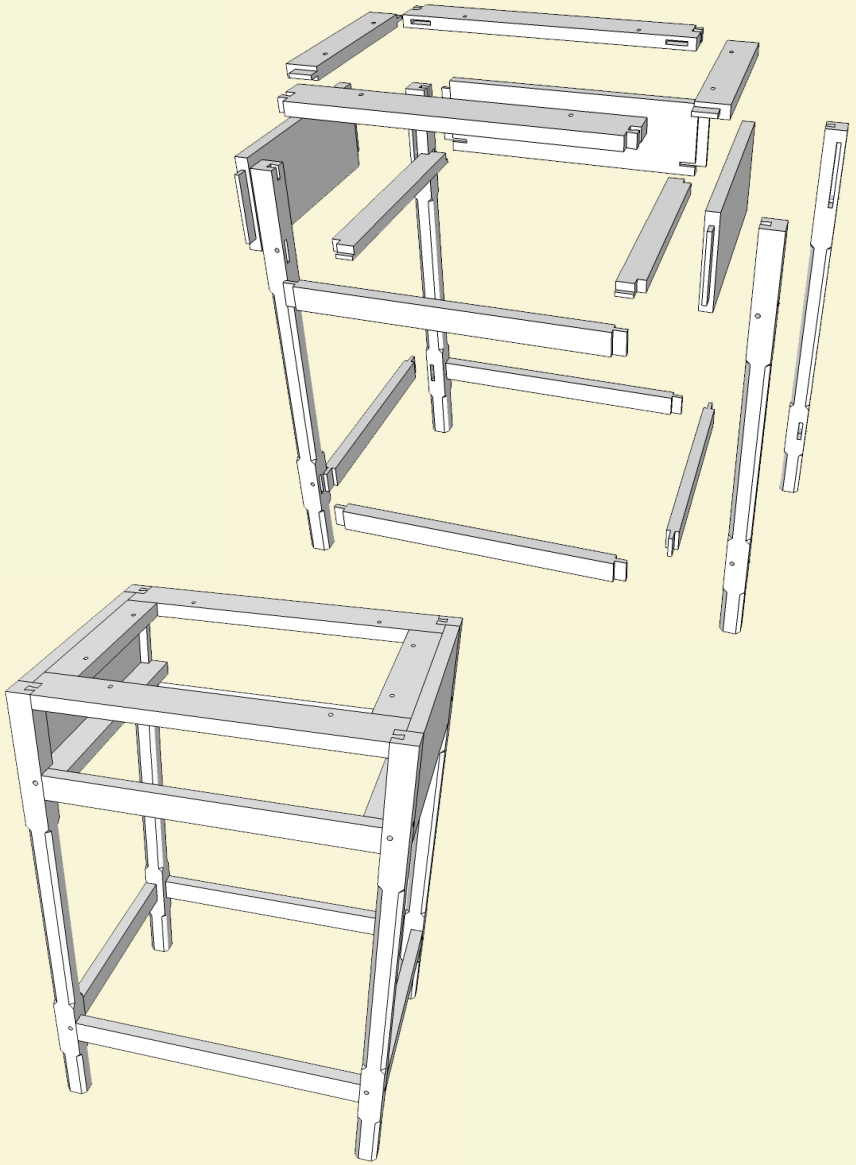
to locate the centers for two overlapping circles (about 9/16 in. from the edge and 3½ in. from the end), as shown in Figure 35, then draw the circles and connect them with lines to shape the slot. The slot face may disappear after you clean up the waste. Use the Line Tool to trace over a small segment of the hole outline. Then use the Push/Pull Tool to push the hole through. You should have the finished shape shown in the inset to Figure 35. (If you can't make the hole with intersecting circles, try drawing the hole using the Line and Arc Tools.) You can copy this elongated hole and place it strategically at guide line intersections on the rails and stiles.

When you copy the hole, you may see that the copy doesn't appear to go through the frame component; all you will see is the outline of the hole. To fix that, zoom in very close to the hole and trace over a small part of the hole outline. You should then be able to click on the hole and eliminate the bogus face. Do the same on the opposite face of the frame component to clear the hole.

Step 31 Use the Tape Measure Tool to place guide lines that mark the location of peg holes in one front leg (the center of the peg hole is 3/8 in. away from the inner edge of the leg). The holes are staggered on adjacent faces to avoid creating an interference with the driven pegs. (I used about a 3/8-in. offset.) Then use the Circle Tool to create a ¼-in.-diameter circle on the face of the leg. Use the Push/Pull Tool to push the circle, creating a hole that goes about ¼ in. beyond the far edge of the mortise. Switch to X-Ray

Status Report

With the addition of peg holes in the legs, we've completed the table design, except for the top and the drawer.



View to check the relative positions and clearances of the holes.

Rough-Out the Top, Then Add Breadboard Joint Details

Step 32 Use the Tape Measure Tool to place guide lines to locate the boundary of the tabletop, including the breadboard ends. Begin by placing guide lines at the midpoints of the front and side components. (SketchUp will display a cyan dot and the word "Midpoint" when you're at the correct position.) Then add guide lines to each side of those centerlines, placing the new guides one half the width or length of the top—including the breadboard ends—to outline the perimeter of the tabletop centered on the lower structure. Use the Line Tool to trace over the guide lines to create a face for the top, as shown in Figure 36.

Step 33 Place guidelines at each end of the top face to mark the width of the breadboard ends. Use the Line Tool to trace over the guide lines. Select the center portion of the face and make it a component named Top. Use the Push/Pull Tool to make the top ¾ in. thick. Follow the same procedure for one of the breadboard ends, as shown in Figure 37.

Step 34 Make a temporary copy of the top component and move it a short distance away from the assembled table. Draw guide lines to define the ¼-in. tongue on the sides. Use the Line Tool to trace over the guide lines and use the

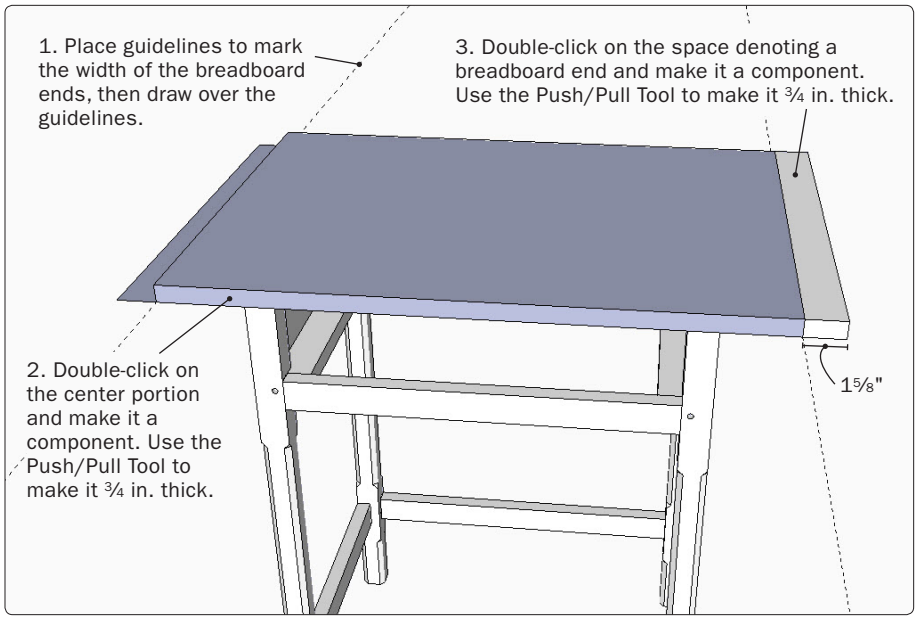


Figure 37. *Create components for the top and one breadboard.*

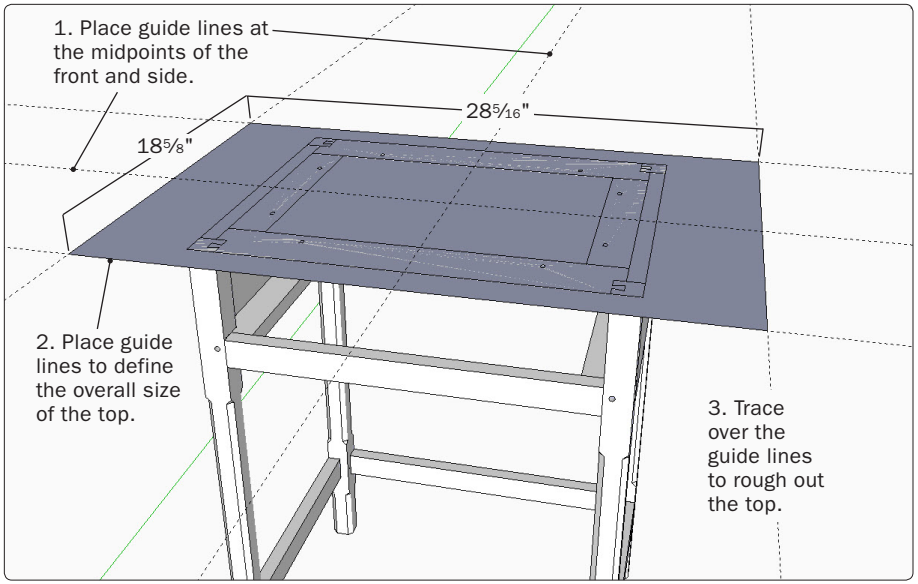


Figure 36. *Begin laying out the top by drawing a face for its overall length and width.*

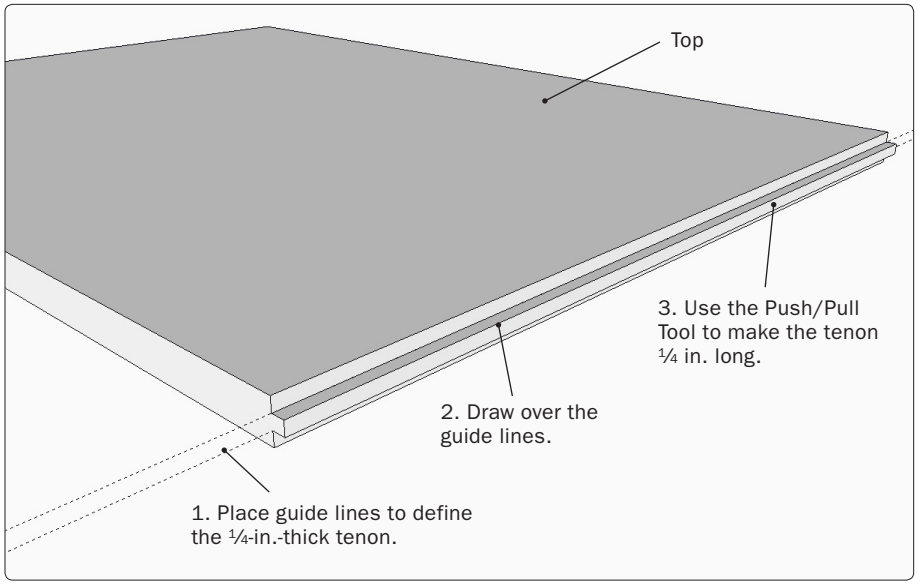


Figure 38. *Create a short tenon on the end of the tabletop.*

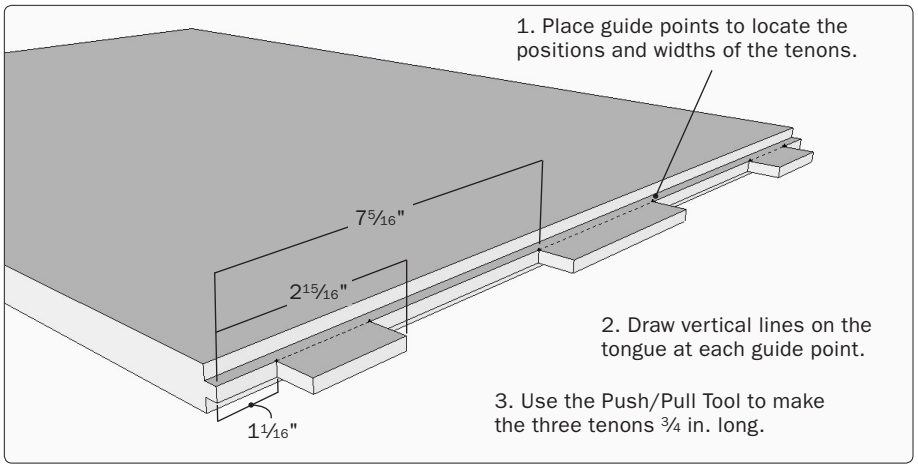


Figure 39. *Create the three longer tenons on the top.*

Push/Pull Tool to make the tongue the proper length, as shown in Figure 38.

Step 35 Use the Tape Measure Tool to place guide points at six positions along the tongue to define the longer tenon locations. (To learn how to place guide points, see page 17.) To place the guide points precisely, type the exact dimension you want and press the Enter key. Draw vertical lines at the guide points to create the sides of the long tenons. Use the Push/Pull Tool to make the tenons the proper length (Figure 39).

Step 36 As you did when making other tenons, copy the tongue and tenons and move the copy to the opposite end of the top. Use the Flip Along command to orient the tenons and tongue properly, then connect the copy to the top, as shown in Figure 40. When you have finished placing the tenons, delete the copy of the top component.

Step 37 Figure 41 is an orthographic view of the breadboard, giving all the necessary dimensions for the position of the mortises and peg holes. Refer to this figure as needed when you shape the component.

Step 38 As you have before, use the tenons on the top component to shape the mortises and groove in the breadboard end. In the View Menu, switch the face view to X-Ray View. Select the breadboard end component for editing. Trace over the tenons on the face of the breadboard end. Use the Orbit and Zoom Tools as needed to clearly see and locate the edges of the joint. Push the appropriate arrow keys while drawing lines to stay on the proper axis. In this case, the left arrow key will constrain the line to the green axis. Use the Push/Pull Tool to make the groove in the breadboard. Then draw vertical lines on the breadboard to define the widths of the three mortises. (Figure 42).

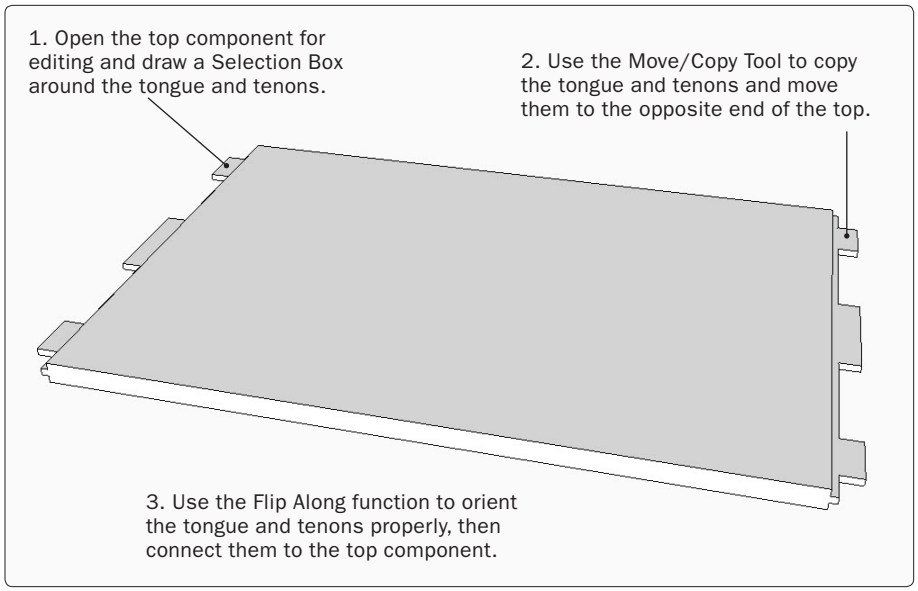


Figure 40. *Copy the tongue and tenons and move them to the opposite side to finish the top component.*

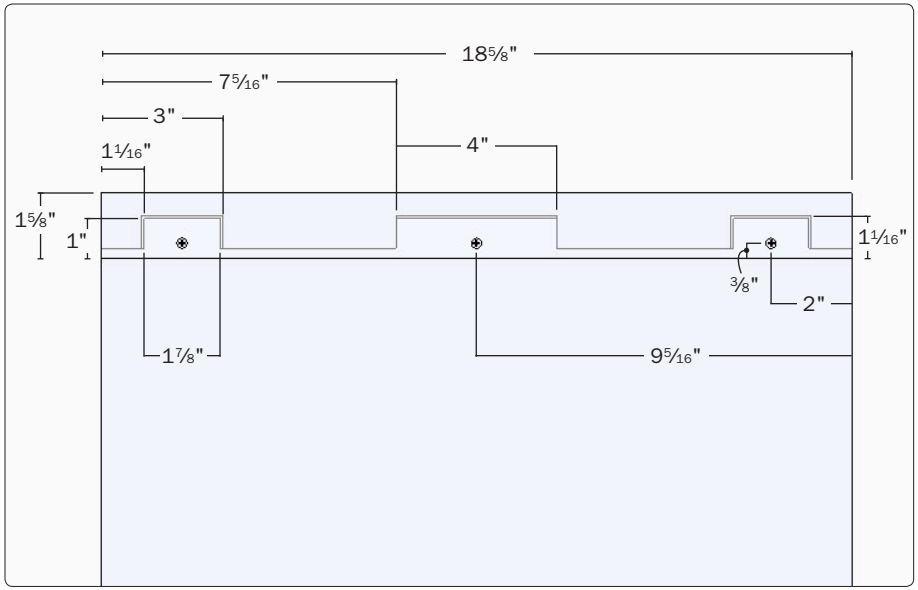


Figure 41. *Dimensions for the mortises in the breadboard end.*

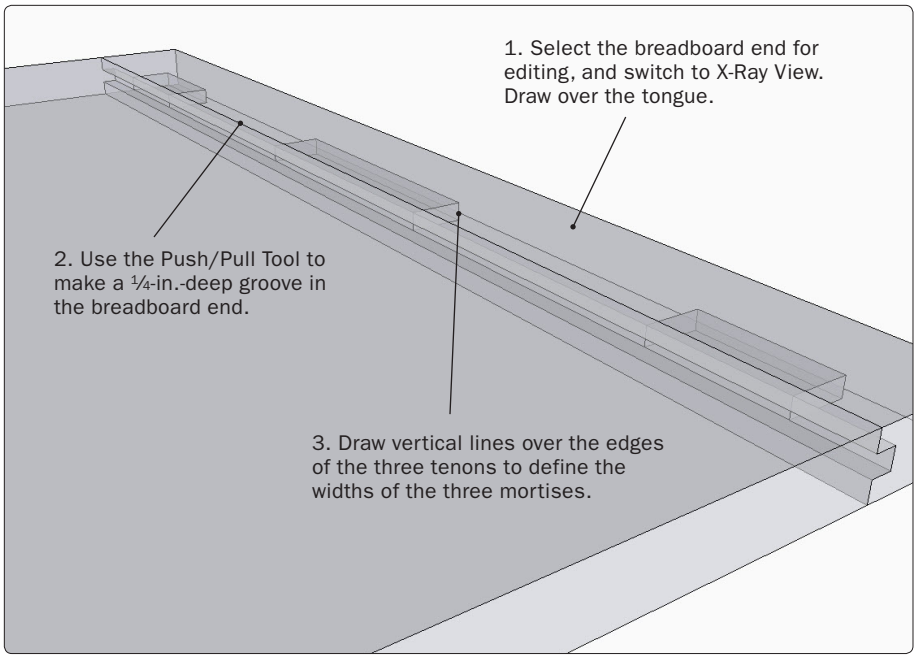


Figure 42. *Use the tenon on the top to make the groove in the breadboard end.*

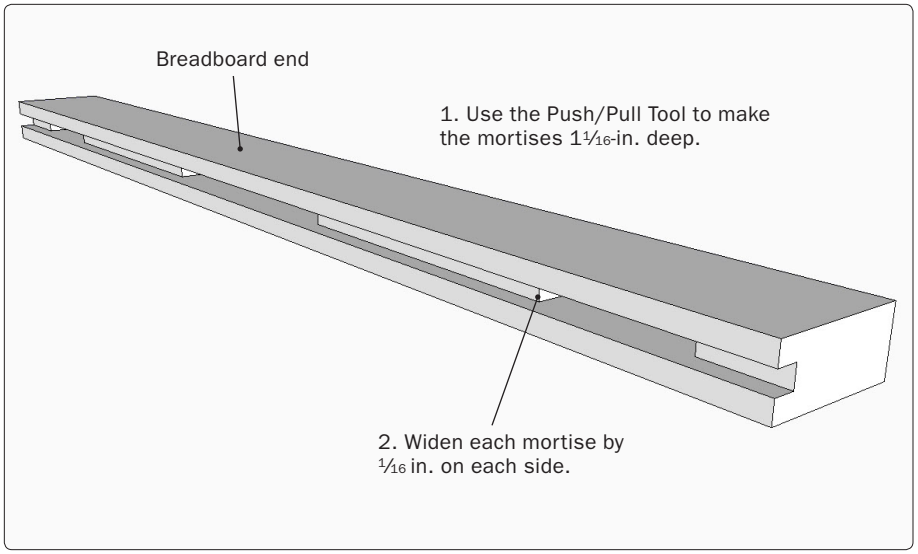


Figure 43. *Work on a copy of the breadboard end to create the mortises.*

Step 39 Make a copy of the breadboard and move it away from the other components. Use the Push/Pull Tool to make the mortises the proper depth. Extend the width of the two end mortises 1/16 in. on each side to allow for expansion and contraction of the tabletop within the breadboard (Figure 43). When you've finished, delete this copy.

Step 40 Create the peg holes at the ends of the breadboard. Place guidelines to locate their centers. Use the Circle Tool to create a circle on the top face, then use the Push/Pull Tool to push the hole all the way through the breadboard. You don't need to show corresponding holes in the tenons. (Figure 44).

Step 41 Copy the completed breadboard and move it to the opposite end of the top. Right-click on the copy and use the Flip Along function to orient it properly. Use the Move/Copy Tool to connect the breadboard to its final position.

Design the Drawer

The drawer is a typical 18th-century design featuring hand-cut dovetails and a solid bottom with a beveled edge. Figures 45–51 show how the parts fit together and provide all the necessary dimensions. Refer to the figures as needed as you design the drawer.

Step 42 Use the Line and Push/Pull Tools to draw the drawer side, then make it a component. Shape the dovetails on the front end, beginning at the top and bottom corners. As shown in Figure 52, place guide lines ¼ in. from the top and bottom edges of the side

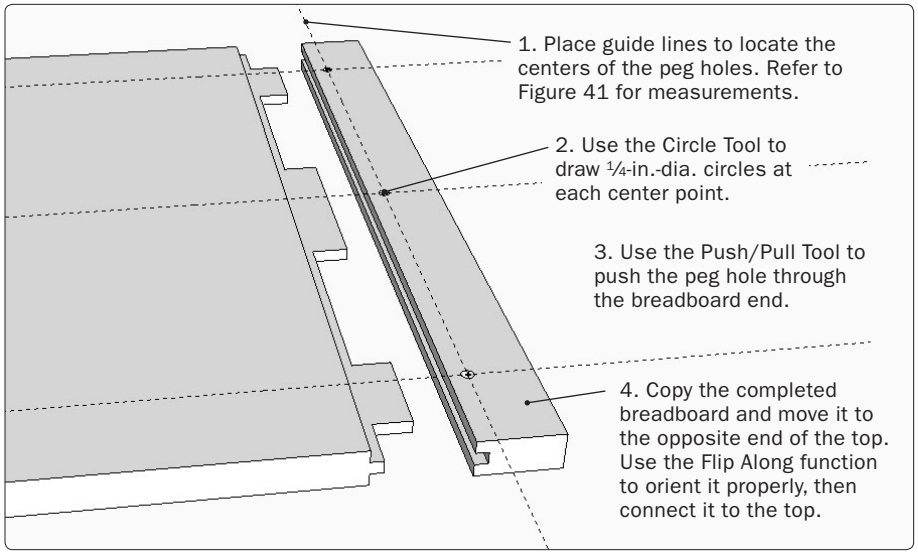


Figure 44. *Create peg holes in the breadboard end.*

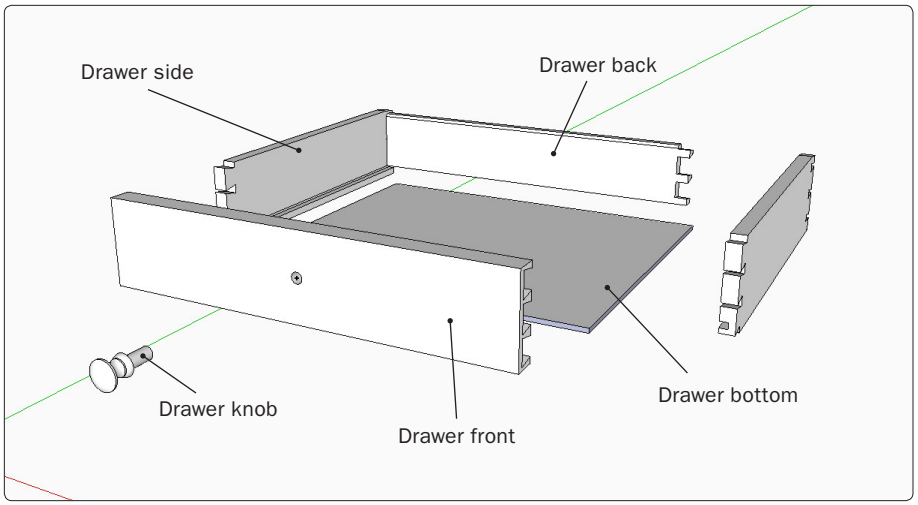


Figure 45. *Exploded view of the drawer.*

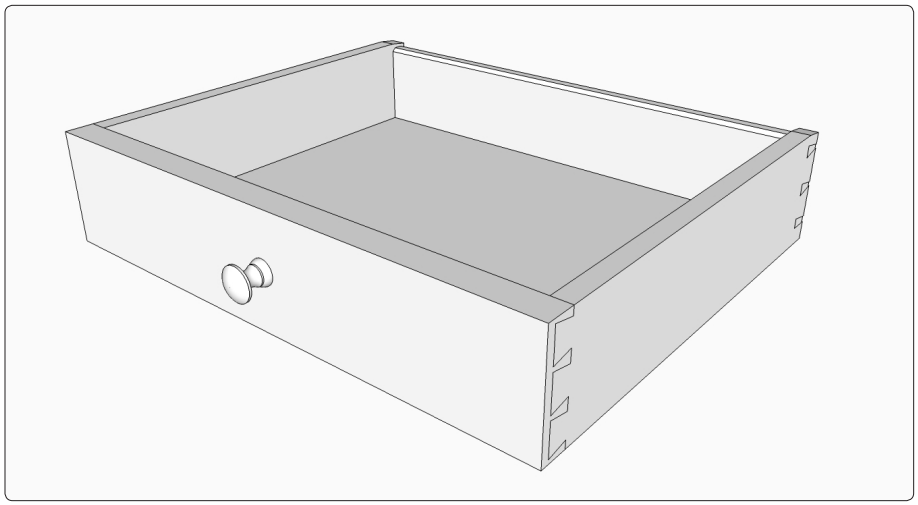


Figure 46. *Assembled view of the drawer.*

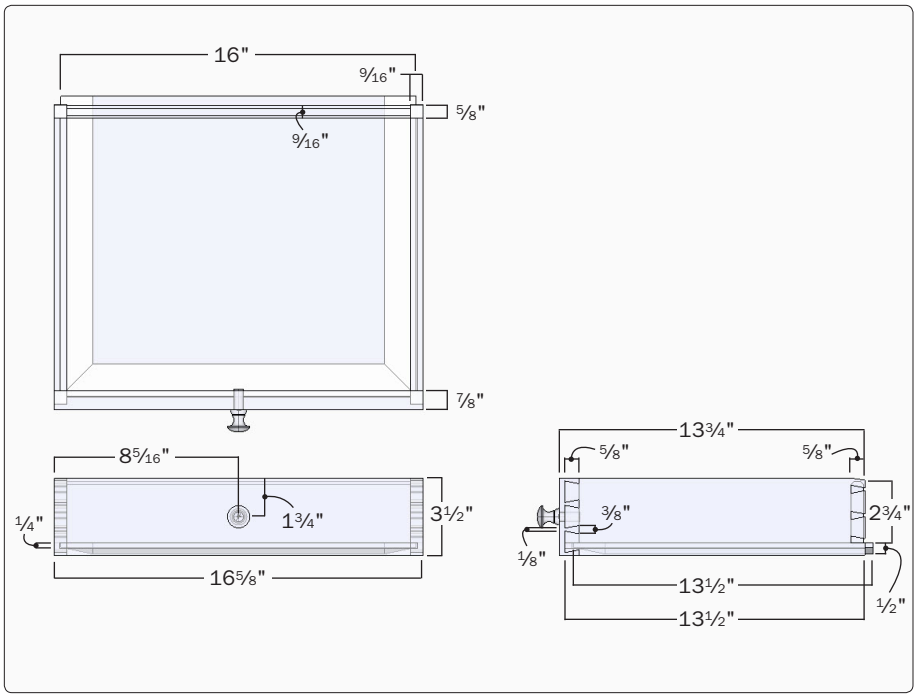


Figure 47. *Front, top, and side views of drawer*

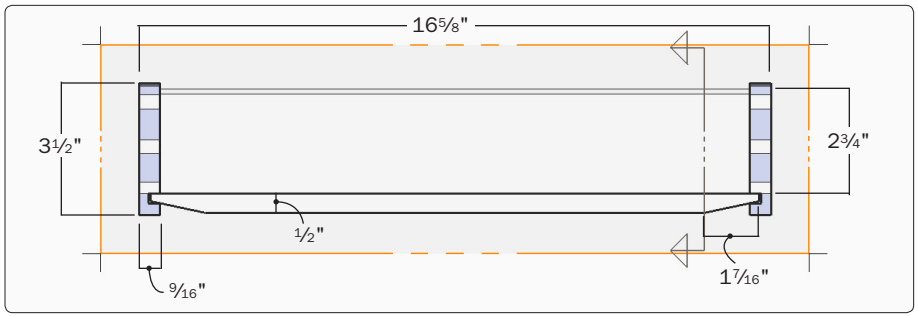


Figure 48. *Front cross-section of drawer.*

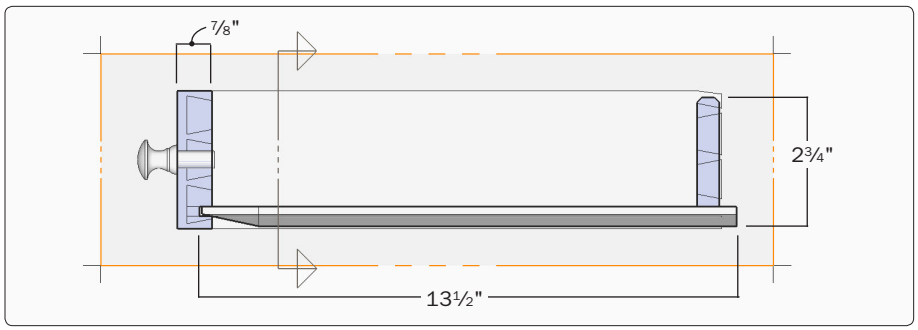


Figure 49. *Side cross-section of drawer.*

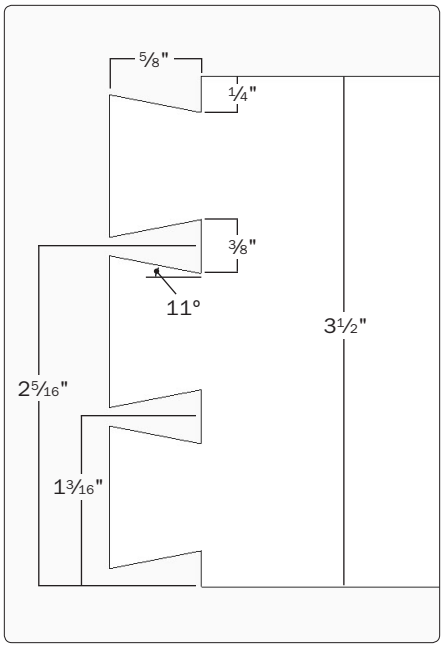


Figure 50. *Measurements for the front dovetails.*

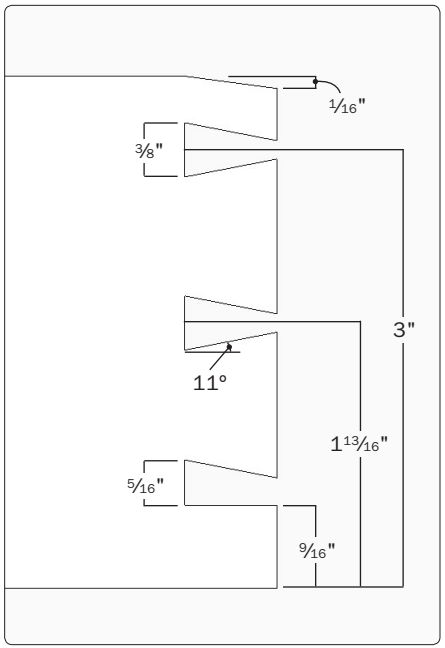


Figure 51. *Measurements for the rear dovetails.*

and another guide line 5/8 in. from the front edge. Select the Protractor Tool and place its center on the intersection of the guide lines; create an 11-degree angle at each intersection. Select the side component for editing and use the Line Tool to trace over the dovetail shapes. Use the Push/Pull Tool to remove the waste.

Step 43 To draw the remaining dovetails and space them evenly, use the same procedure described in Chapter 7. Draw a vertical line from top to bottom. Right-click on the line and select Divide from the pop-up menu. Select the line and move the mouse until the pop-up window indicates that it's been divided into three segments. Click the mouse to set the divisions. As shown in Figure 53, place guide lines at the breakpoints of this segmented line. Click the Tape Measure Tool on the bottom edge of the side component, then move the mouse along the blue axis to the first breakpoint; you'll see a green dot on the line when you've reached the breakpoint. Click the mouse to place the guide line. Place guide lines as shown on both sides of the dovetail midpoint. Use the Protractor Tool to place guide lines at 11 degrees to complete the dovetail shape. Select the side component for editing and use the Line Tool to trace over the shape of the dovetail. Use the Push/Pull Tool to eliminate the waste. Use the Select Tool to draw a left-to-right Selection Box around the dovetail you just drew. Use the Zoom and Orbit Tools as needed to be sure you've selected the entire dovetail. Copy the dovetail and move it down along the blue axis until it aligns with

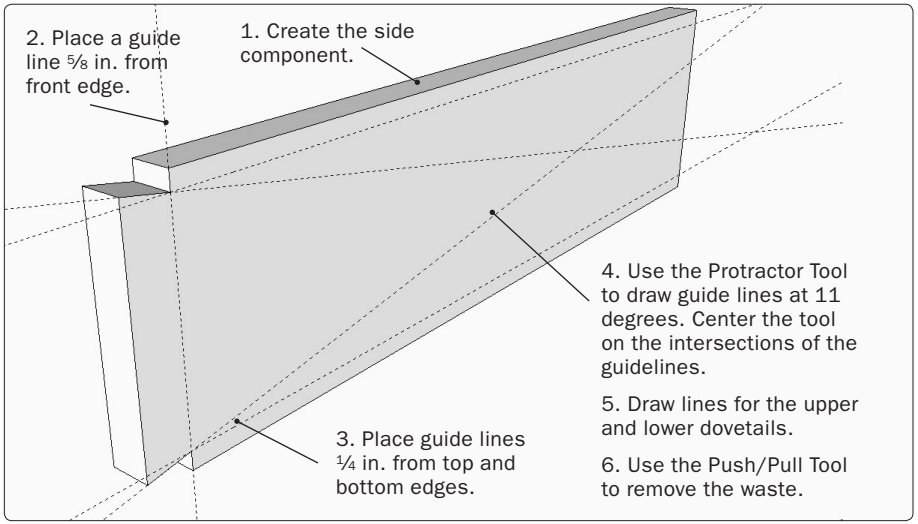


Figure 52. *Begin laying out and shaping for the front dovetails.*

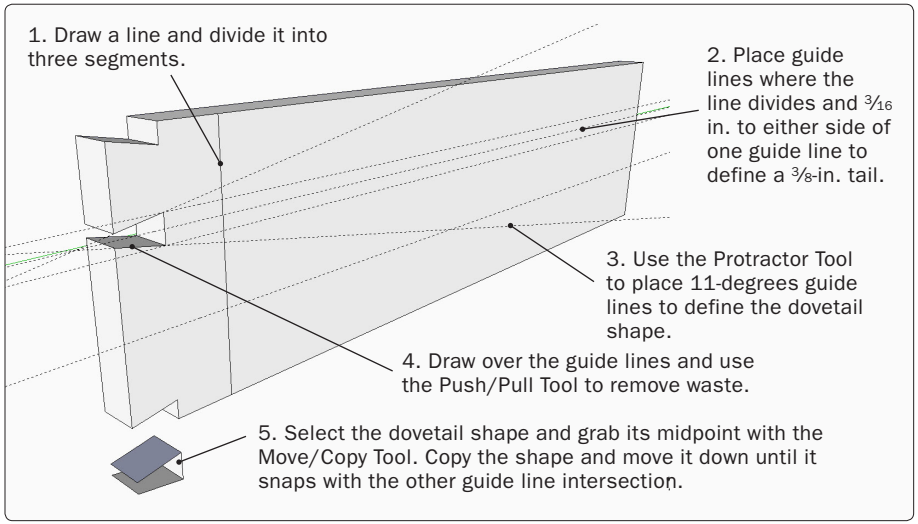


Figure 53. *Complete the front dovetails.*

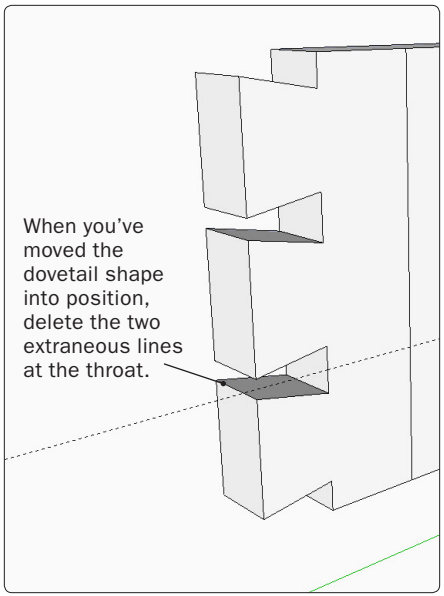


Figure 54. *Completed front dovetails.*

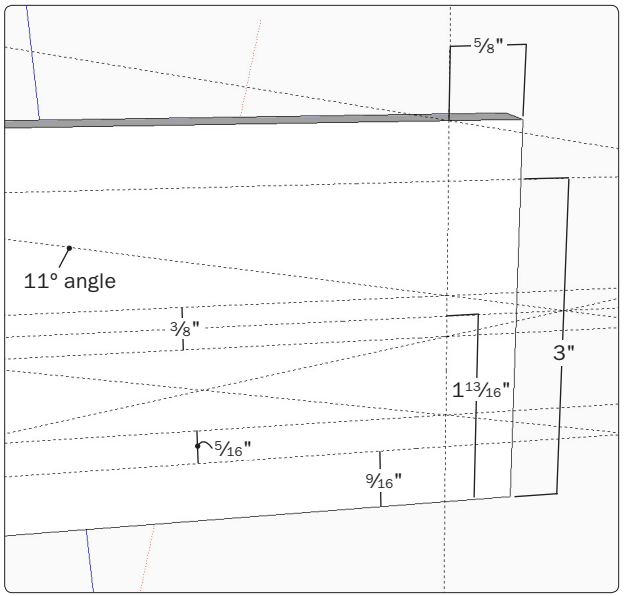


Figure 55. *Place guidelines to lay out the rear dovetails.*

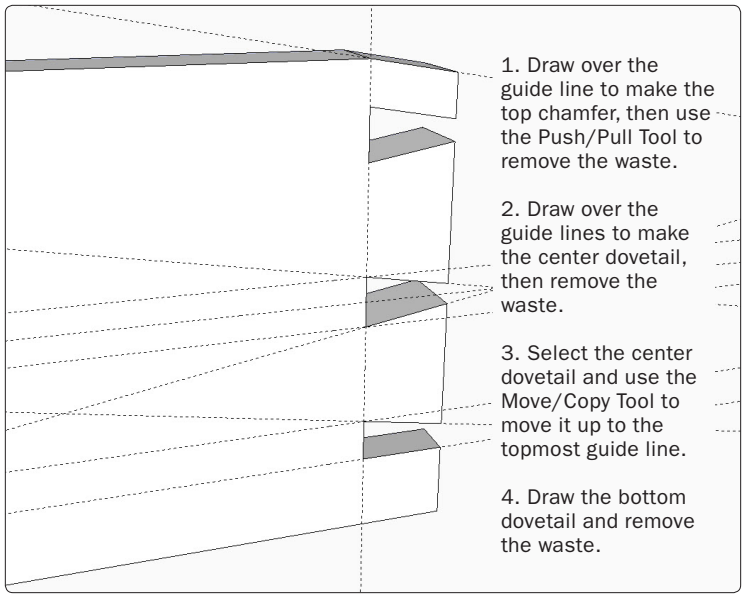


Figure 56. *Complete the rear dovetails.*

the guide line, as shown in Figure 54. Delete the two extraneous vertical lines at the throat of the dovetail.

Step 44 The rear dovetails are similar but not identical to those on the front, as Figure 51 shows. Use the Tape Measure Tool to place all the layout lines shown in Figure 55. Use the Protractor Tool to draw the angled guide lines, which are all 11 degrees.

Step 45 Use the Line Tool to draw the chamfer on the top edge, then use the Push/Pull Tool to remove the waste. Next, as you did on the front dovetails, draw the center dovetail and remove the waste. Again as you did on the front, choose Edit Component, select the center dovetail by drawing a Selection Box around it, copy it, and move it up to connect it with the appropriate guide lines. Draw the bottom dovetail and remove the waste (Figure 56).

Step 46 Use the Orbit Tool to view the front end of the side component so you can add the groove on its inside face. Place a guide line to locate its top edge, as shown in Figure 57. Draw a square on the end of the component, then use the Push/Pull Tool to push the groove to the back edge of the drawer side. Creating the groove this way leaves a small rectangular shape at the back of the side. Use the Eraser Tool to delete this waste, as shown in Figure 58

Step 47 Arrange the drawer sides at their proper orientation and separation.

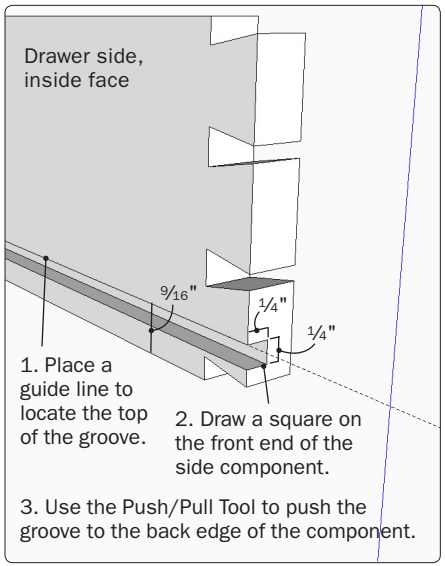


Figure 57. *Make the groove that will hold the drawer bottom.*

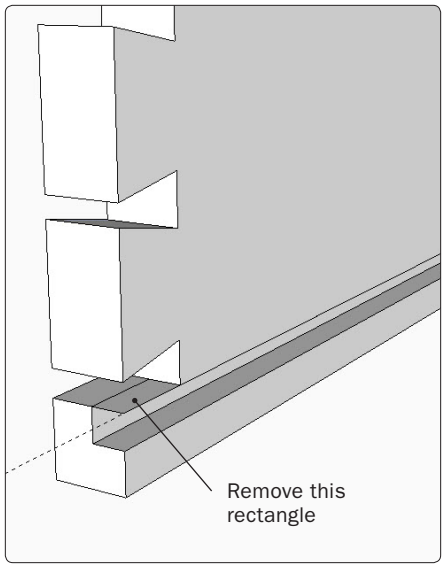


Figure 58. *Delete waste at the top of a rear dovetail.*

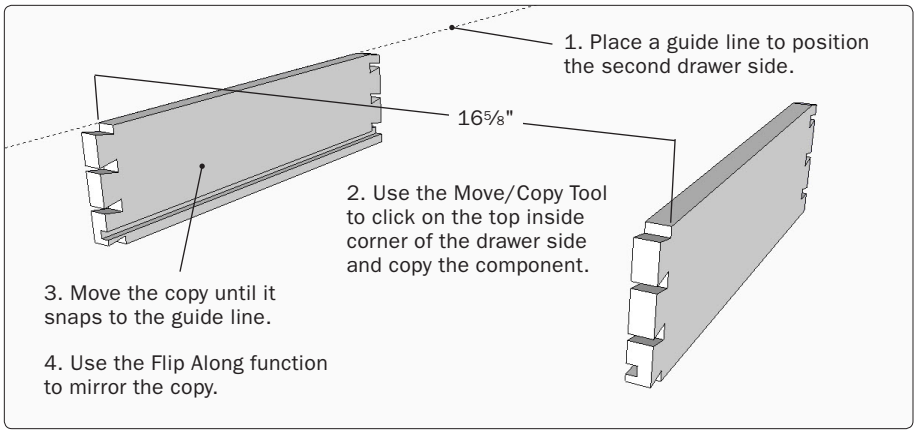


Figure 59. *Copy the drawer side and place it in position.*

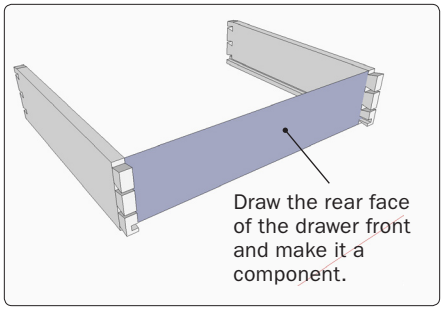


Figure 60. *Rough in the drawer front.*

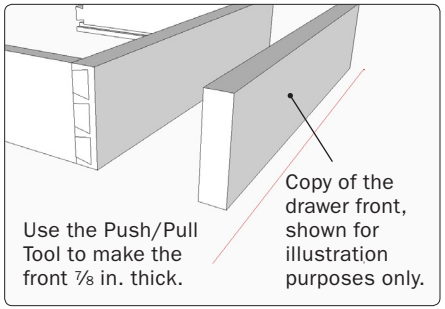


Figure 61. *Make the front the proper thickness.*

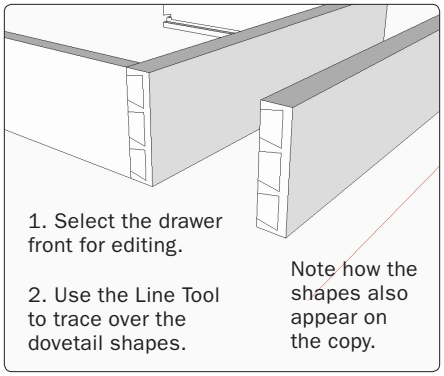


Figure 62. *Create the half-blind dovetail shapes in the drawer front.*

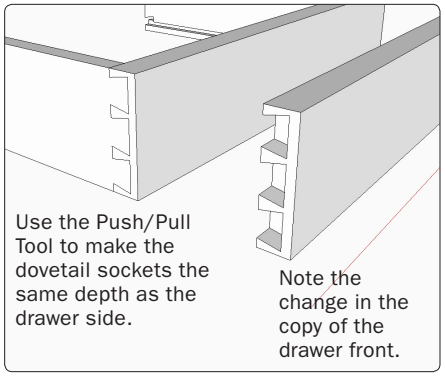


Figure 63. *Push the dovetail sockets to the proper depth.*

Place a guide line, as shown in Figure 59, to locate the second side component. Use the Move/Copy Tool to copy the side component and move it along the red axis until it snaps to the guide line. Push the right arrow key to keep the copy on-axis. Right-click the copy, and use the Flip Along command to orient the copy properly.

Step 48 Begin drawing the drawer front in position between the drawer sides. Draw one face (it will be the back face) aligned with the dovetail shoulders, as shown in Figure 60. Begin drawing at the top outside corner of the dovetail shoulder on the left side, and extend the line to the top outside corner of the shoulder on the right side. Continue drawing to complete the rectangle. Make this face a component.

Step 49 Use the Push/Pull Tool to make the drawer front the proper thickness. Figure 61 shows a copy of the front component placed in front of the drawer. This will help show how to create the half-blind dovetails in the component.

Step 50 Right-click on the drawer front and choose Edit Component from the pop-up menu. Use the Line Tool to trace over the dovetail shapes. The lines will also appear on the copy, as Figure 62 shows.

Step 51 Use the Push/Pull Tool to make the dovetail sockets the same depth as the drawer side (Figure 63). To ensure you push to the correct depth, click the mouse on the back edge of the side component.

Step 52 Select the dovetail sockets and use the Move/Copy Tool to copy and move them to the opposite end of the component, as shown in Figure 64. It's

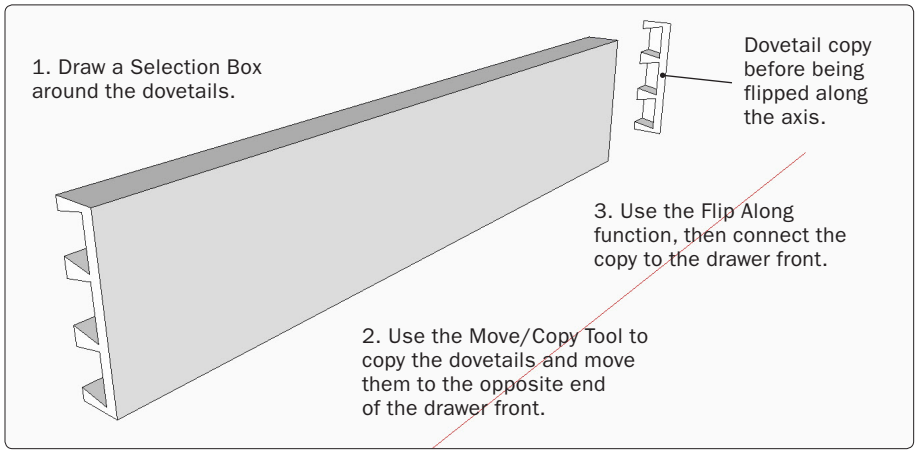


Figure 64. *Copy the half-blind dovetails to the other end of the drawer front.*

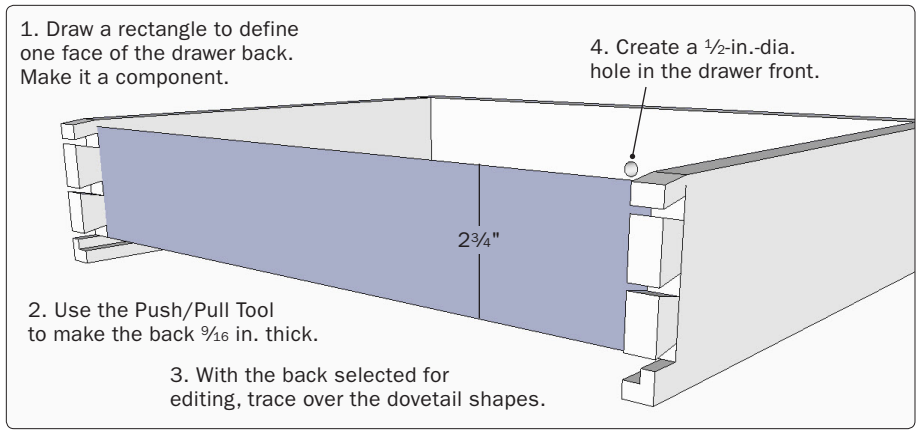


Figure 65. *Create the drawer back.*

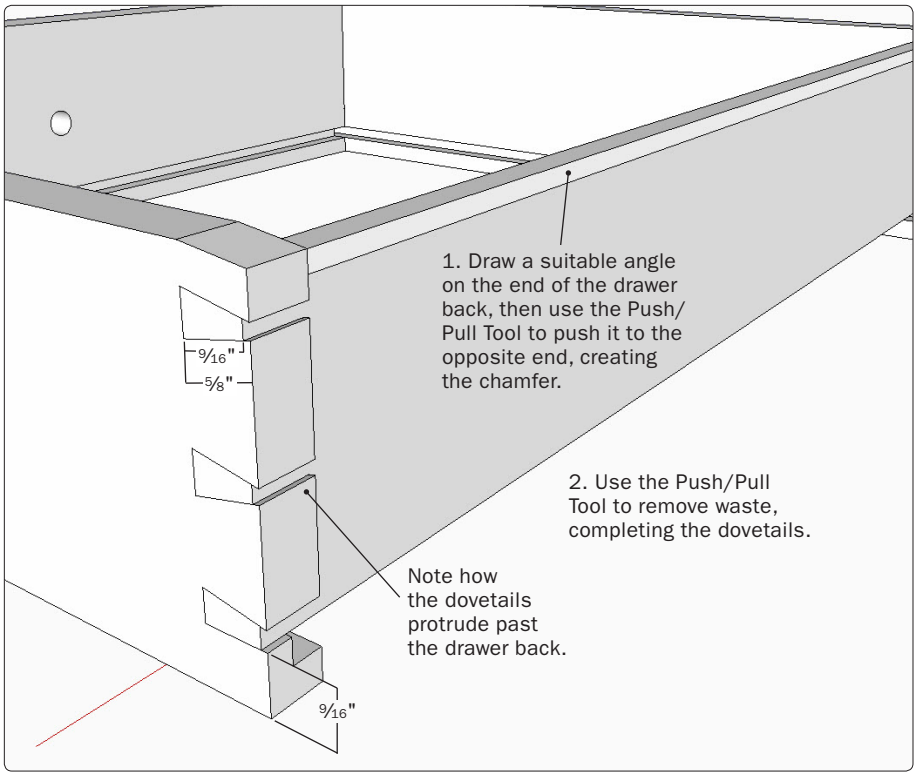


Figure 66. *Shape the dovetails and a chamfer to complete the drawer back.*

the same procedure you have used to duplicate tenons. Use the Flip Along function to orient the copy properly. Use the Orbit Tool to rotate around the front component and create the ¼-in. by ¼-in. groove on the back to accommodate the drawer bottom.

Step 53 Create the drawer back the same way you did the front. The bottom edge of the back piece aligns with the top of the groove in the sides. Use the Line Tool to draw the rectangle shown in Figure 65. Make it a component. It should stretch from the outside face of one side component to the outside face of the other side. Use the Push/Pull Tool to give the drawer-back component the proper thickness. With the back component drawn and selected, trace the dovetail shape on one end, and then use the Push/Pull Tool to finish the joint, as shown in Figure 66.

Copy the back and move it away from the drawer assembly. Next, copy the dovetails to the opposite end. Add a chamfer to the top edge by drawing sloped lines on the end and pushing out the waste with the Push/Pull Tool. The size of the chamfer isn't critical; see the amount of chamfer in Figure 49.

Delete the copy of the drawer-back component.

Use the Orbit Tool to view the drawer front. Use the Circle Tool to draw a circle in the middle of the drawer front for the drawer pull, then use the Push/Pull Tool to push this circle face through to the back of the piece. Place a guide point at the center of the hole by right-clicking on the circle perimeter and choosing Point at Center from the pop-up menu. The guide point will help position the drawer knob.

Step 54 The drawer bottom has a beveled edge on two sides and the front. The back edge of the bottom is square. You'll use the Follow Me Tool to create the bevels. The tool requires a shape and a path on which the shape is extruded.

Begin the drawer bottom design by creating the shape of the beveled edge, as shown in Figure 67. Use the Tape Measure and Protractor Tools to place the guide lines shown, then use the Line Tool to trace over the guide lines to create the bevel shape. You should now have the trapezoidal shape shown. Double-click on this shape and make it a component.

Step 55 To prepare for the Follow Me operation, draw a path that follows the exact outline of the inner edge of the drawer sides and front. Draw vertical lines down from the inner corners of the side components. Use these lines to guide the drawing of the path, as shown in Figure 68. Push the appropriate arrow keys to keep your lines on-axis.

Step 56 Select the path by clicking on each line segment while holding down the Shift key. Then select the Follow Me Tool (it's just below the Move/Copy Tool), and hover the cursor over the bevel-edge component. Click the mouse. That will extrude the bevel shape along the path, generating

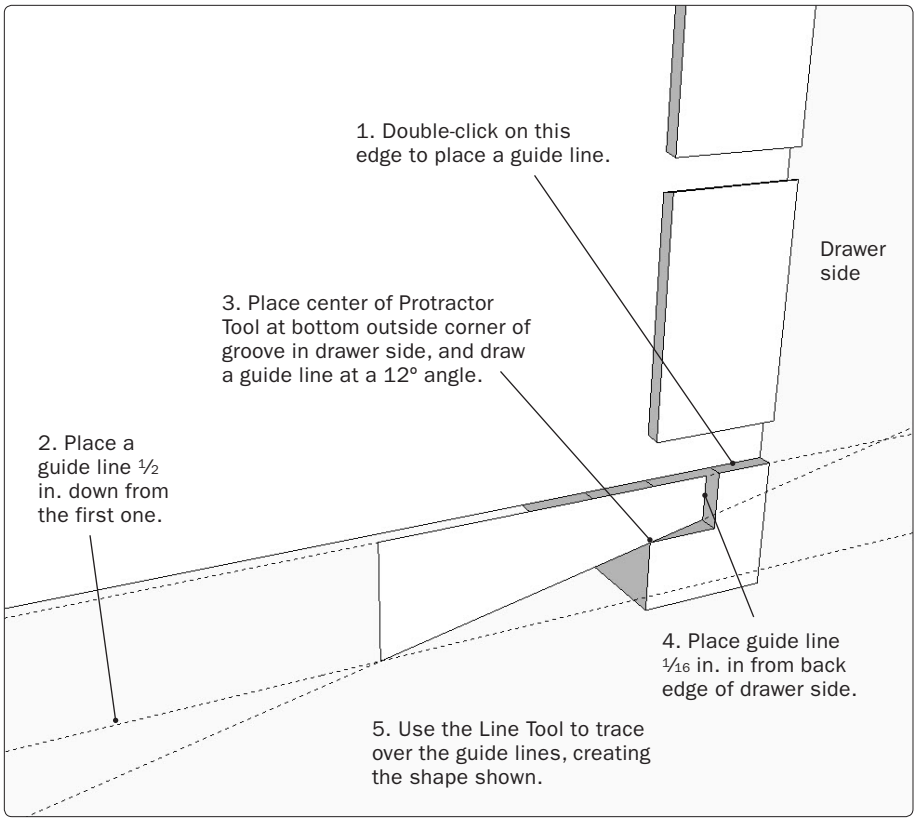


Figure 67. *Begin roughing in the drawer bottom by creating its beveled edge.*

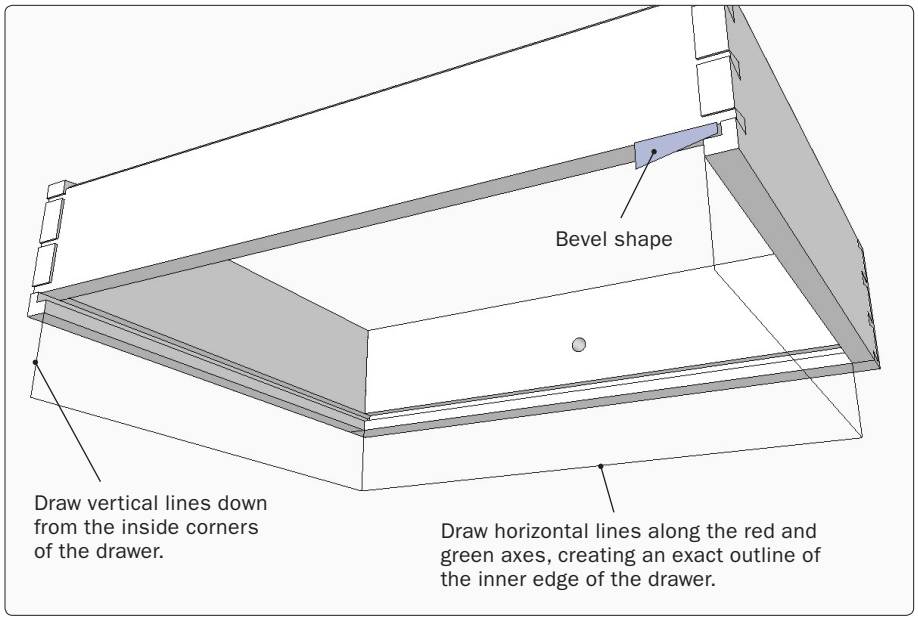


Figure 68. *Draw a path so that the Follow Me Tool can extrude the beveled edge.*

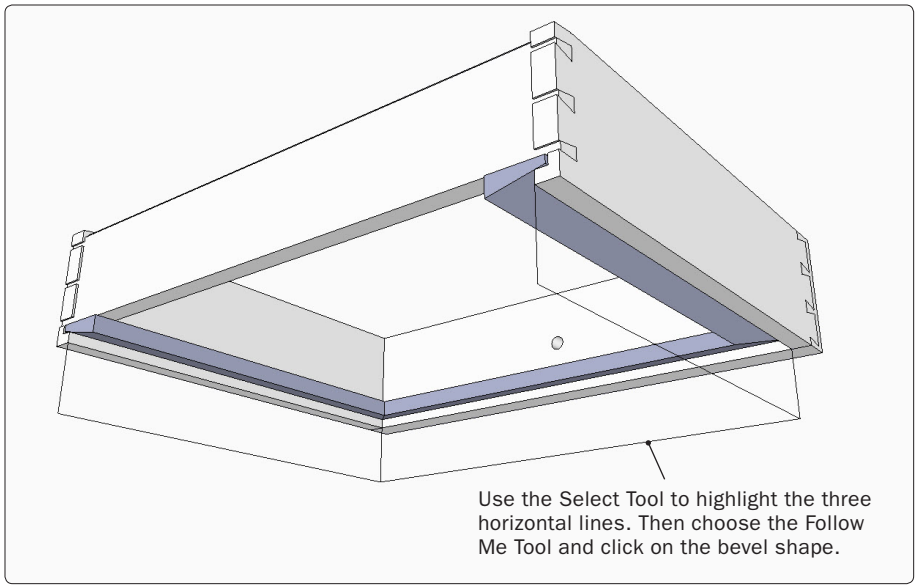


Figure 69. *Use the Follow Me Tool to create the bevel shape.*

the beveled edge of the drawer bottom fitted precisely in its groove, as shown in Figure 69. Delete the vertical lines and the path.

Step 57 Copy the bevel-edge component and move it away from the assembled drawer. Then draw lines to fill in the center of the drawer bottom (Figure 70).

Step 58 Use the Line Tool to draw connecting lines on the rear edge of the drawer bottom to complete the face of the component. Also, use the Orbit Tool to rotate around to see the top face. Delete the extra lines there (Figure 71). Delete the copy of the drawer bottom.

Turn the Drawer Knob

Figure 72 shows a perspective view of the drawer knob, which is 1 in. in diameter. I created this shape from a knob I found in a book about period furniture. I scanned a drawing of the knob and imported it into the SketchUp plan as a

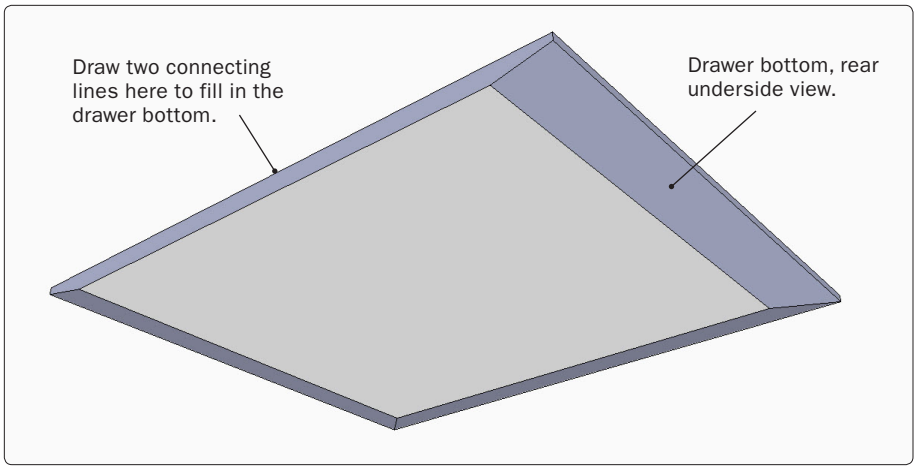


Figure 70. *Add lines to finish shaping the drawer bottom.*

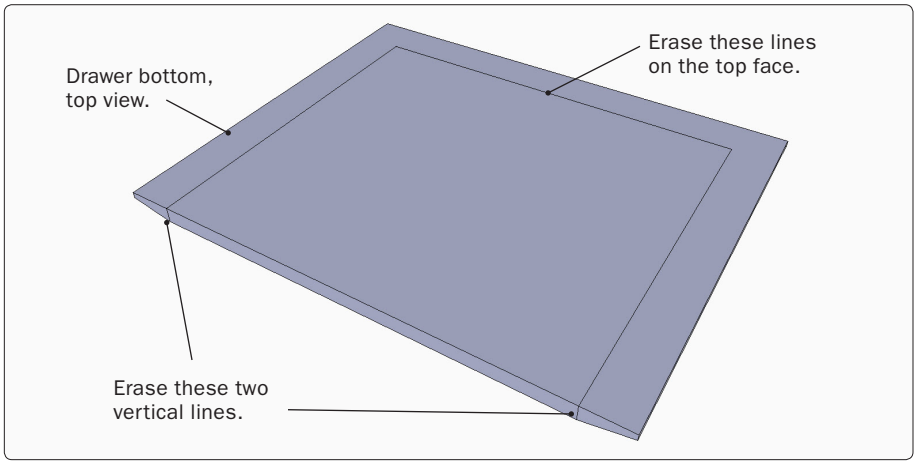


Figure 71. *Erase the extra lines to complete the drawer bottom.*

jpg image. Once I'd oriented the image on a SketchUp axis and scaled it, I traced over it to create the two-dimensional view shown in Figure 73.

When you simulate turning in SketchUp, you first create this kind of flat profile of the object, which you use with the Follow Me Tool. Of course, you don't have to import an image; you can simply draw whatever pleasing shape you like. If you do that, draw it in an orthographic view.

Step 59 In the Camera Menu, choose Parallel Projection and Front View. Draw a rectangle, then use the Line and Arc Tools to draw the knob profile within the rectangle, using Figure 73 as a guide. This helps ensure that all lines and arcs are on the same plane. When you have the shape you want, erase any extraneous lines.

Step 60 Use the Line Tool to extend one edge of the profile, as shown in Figure 74. These lines help you locate the centerline of the component after it is turned so that you can put it in place on the drawer front. Use the Circle Tool to create the path for the Follow Me Tool, as shown in Figure 74.

Make the circle with its radius on the blue axis to align with the face of the shape. This will ensure that you end up with a clean extrusion, without small anomalies on some facets.

Step 61 To produce best results, scale this component to 10 times normal size. If you don't scale up, the resulting shape will have a hole in the middle of the knob. Select the profile and the circle. Select the Scale Tool, grab one of the yellow corner handles that now surround the shape you have drawn, and type a multiple of 10.

You may have to use the Zoom Tool to see the entire component. Click on the circle to select it as a path, then choose the Follow Me Tool and hover over the knob shape. Click the mouse to produce the turning, as shown in Figure 75. Make the turning a component.

Step 62 To remove all extra lines, draw a left-to-right Selection Box around the

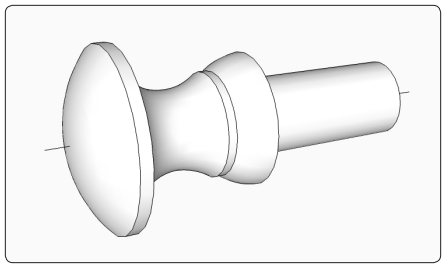


Figure 72. *The drawer knob.*

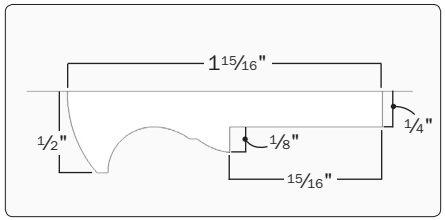


Figure 73. *A two-dimensional view of the knob.*

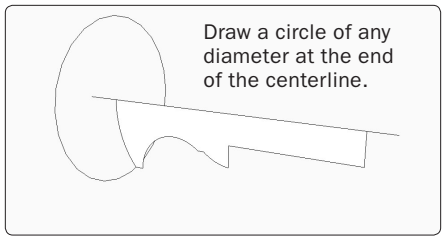


Figure 74. *Make a path for the Follow Me Tool to turn the knob.*

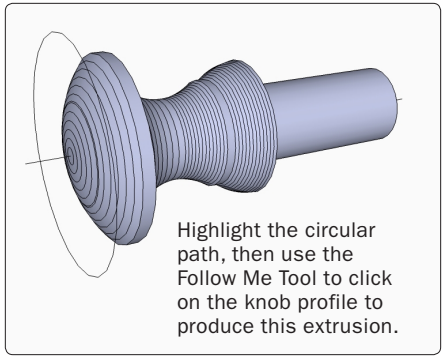


Figure 75. *Execute the Follow Me command.*

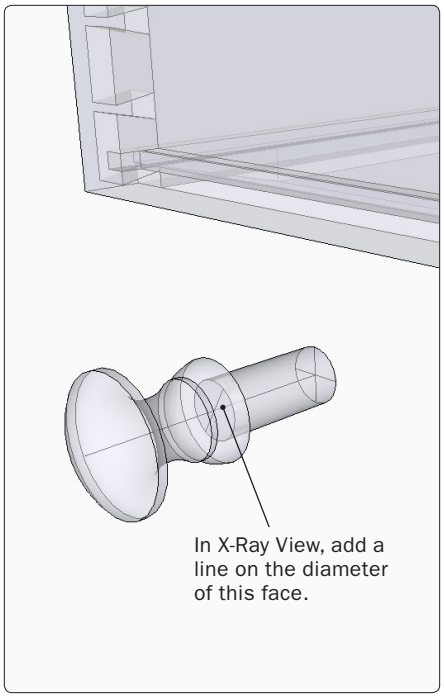


Figure 76. *Add a hidden line to the knob so you can place it precisely in the drawer front.*

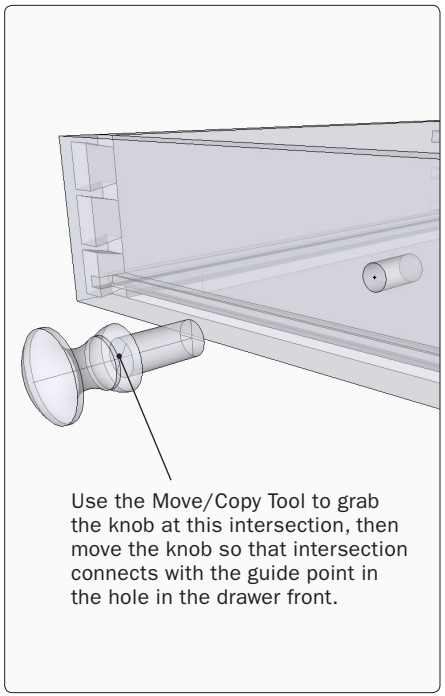


Figure 77. *Finish the table by inserting the knob in the drawer.*

knob to highlight all surfaces and edges. Right-click on the knob and choose Soften/Smooth Edges from the pop-up menu. (I normally have acceptable results with the softening set at the default value of 20 degrees, so there is usually no need to move the slider bar.) Delete the circle that served as the Follow Me path. Use the Line Tool to draw a centerline through the full length of the component. Delete the extra line extending from the face of the knob. Descale the knob by a factor of 0.1 to restore it to its correct size.

Step 63 Turnings do not have corners and intersections to use as handles when connecting to other components. For that reason I turn components with an extra centerline, which is helpful for making a connecting handle. Set the face style to X-Ray View and use the Line Tool to create a diameter on the inner face of the knob's tenon, as shown in Figure 76. The intersection of the centerline with the diameter is a handy grab point for the Move/Copy Tool. Use it to grab the knob handle and move it to connect to the guide point in the hole in the drawer front (Figure 77). Reset the face style and the table design is complete.

The Finished Table

You have just finished a complete, historically accurate piece of furniture and in the process learned how to use all the major tools in the SketchUp kit. Beyond the standard Line, Circle, and Push/Pull Tools, this design required you to develop SketchUp skills in drawing and moving components to precise length; making accurately placed guidelines and guide points; turning a drawer knob; creating a bevel edge; moving and connecting components precisely; and orbiting, zooming, and panning to position views.

Creating this SketchUp design has shown you how to create the following joints and design details:

- **Pinned mortise and tenon joints**
- **Dovetails**
- **Chamfers**
- **Bevels**
- **Breadboard details**
- **Drawer design and construction**

By creating this model in SketchUp, you've developed an understanding that pays off in actual shop construction. You've already experienced the construction of this piece before you've switched on a single shop machine. You've worked through the detailed shaping of each component and the exact joinery involved in its assembly. When you are in the shop, the computer model becomes a powerful reference, readily accessible to show an extra view, provide a missing dimension, or produce a full-size template.

In short, shop work will never be the same after you begin using SketchUp. You'll continually find ways to use this tool to improve and expand your work. It will increase your confidence in tackling more complex work, while reducing mistakes and frustrating rework.

More Tools and Functions

For comprehensive modeling and more complex woodworking projects, you'll need to understand how to use additional tools and functions. In this chapter, I'll show you how to use six of them.

The Follow Me Tool. Moldings and turned components are essential to furniture making. To make those components in SketchUp you use the Follow Me Tool. You had a taste of it in Chapter 9, making the drawer knob and the bevel edge for the drawer bottom.

Intersect. If furniture consisted of only simple rectilinear shapes, with everything joined at right angles, then I suppose there would be no need for the Intersect function. However, fine furniture making often entails making curved components or connecting components at odd angles. A cabriole leg is just one example of a component that can only be created by using SketchUp's Intersect function.

The Scale Tool. Intersections and extrusions aren't always rendered well when you try to create small-scale furniture parts. In those situations, you have to use SketchUp's Scale Tool to enlarge the component to 10 or 100 times its actual size. Once you've completed work on the component, you rescale it to its original size. Scaling also helps size components and other graphics.

The Rotate Tool. Although you can usually rotate a component with the Move/Copy Tool, you need to use the Rotate Tool to rotate an object off-axis or to rotate an object that has not been made a component.

Altering a component with the Move/Copy Tool. You often need to change the length, width, or thickness of a component. If you have to alter a simple rectilinear object, the Push/Pull Tool will suffice. But how do you increase the width of a component if its edge has a complex molding shape? Or how can you lengthen a stretcher with tenons on the ends? The Move/Copy allows you to stretch complex components.

Soften/Smooth Edges. When working with complex shapes, particularly two intersecting pieces, SketchUp makes and shows extraneous lines and edges. You can use the Soften/Smooth Edges function to remove those unwanted elements from view.

I'll use the 18th-century tea table shown in Figure 1 to demonstrate how to use these tools and functions.

A Tea Table Built to 18th-Century Rules

The tea table shown here was designed by Mack S. Headley Jr., the master cabinetmaker at Colonial Williamsburg. He used this table in a *Fine Woodworking* magazine article that described a geometric proportioning system used by 18th-century cabinetmakers. The article, "Applying Classical Proportions," did not provide any joinery or overall dimensions but did show a front view of the table and the sizes of the carvings. That was enough to allow me to extrapolate overall dimensions for a detailed SketchUp model and then to reproduce the table in maple, as shown in Figures 1 and 2.

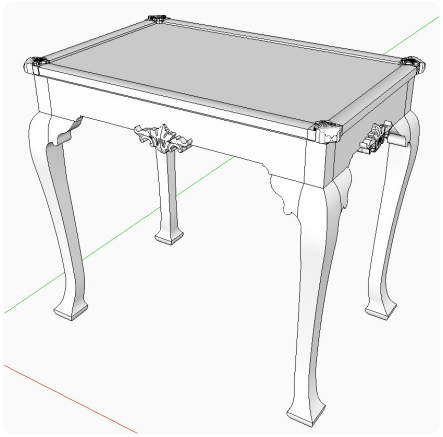


Figure 1. *The Williamsburg tea table in SketchUp.*

Figure 2. *The Williamsburg tea table in curly maple.*

Mastering the Follow Me Tool

The Follow Me Tool is located in the Toolbar, as shown in Figure 3. This tool is mostly used for creating turnings as well as edge or molding shapes around a perimeter. Here are some examples:

- Picture frame moldings.
- Tabletop edge profiles.
- Beveled door panels and drawer bottoms.
- Drawer fronts.
- Base, crown, or cornice moldings.
- The front face of a steam-bent Windsor chair bow.

In general, this tool extrudes shapes along a defined path. You can even extrude a shape along a pipe or tube that

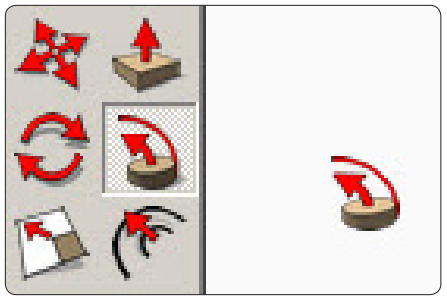


Figure 3. *The Follow Me Tool.*

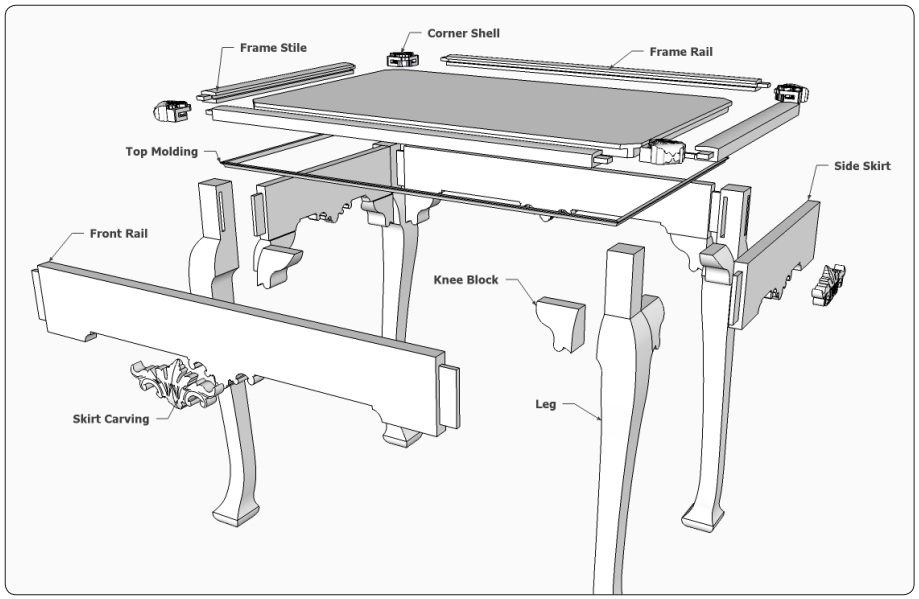


Figure 4. *The top molding on the Willliamsburg tea table is created with the Follow Me Tool.*

snakes along an irregular path through space. If you need to add a molding profile to the edge of a straight piece, the Push/Pull Tool will work fine. But when the molding shifts direction or must follow a complex path, you need to use the Follow Me Tool.

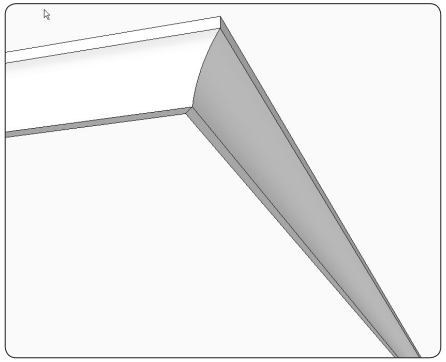


Figure 5. *The top molding in closeup.*

This tool is often used to make mitered joints because it will shift the molding shape around a 90-degree corner (or any other angle, for that matter). The Follow Me Tool does not actually create a miter joint; that requires a few additional steps, which I'll cover on page 68. This chapter concentrates on non-turning uses of the Follow Me Tool. I'll show turning examples in later chapters.

To use the Follow Me Tool, follow these basic steps:

Step 1 Create the specific profile to be extruded or routed. This usually involves using the Line and Arc Tools.

Step 2 Make a path with the Line, Rectangle, Arc, or Circle Tools. For a picture frame, for example, use the Line or Rectangle Tool to draw a rectangular path. You can also define a path by selecting individual edges in the blank pieces to be shaped.

Step 3 If necessary, scale up the size of the shape and path to avoid having very small graphical facets that don't close properly in SketchUp.

Step 4 Highlight the path with the Select Tool.

Step 5 Select the Follow Me Tool and click on the face of the shape.

Step 6 If necessary, create faces at a miter joint so that you can separate the individual pieces and make them components.

As shown in Figure 4, there is a small molded frame that fits just under the top frame. Figure 5 isolates the molding to better show its shape.

To make this molded frame, begin by creating the shaped face shown in Figure 6. You can make the shape a component, which will become the component name for the entire frame.

Use the Line Tool to create a rectangular path for the molding, as shown in Figure 7. (If you made the shape a component, open it for editing before drawing the path.) Draw the path the exact length and width of the finished molding, and be sure that all four lines are on-axis. The path and the molding shape do not have to touch, but the path should be drawn so that the finished molding can easily be connected to the model.

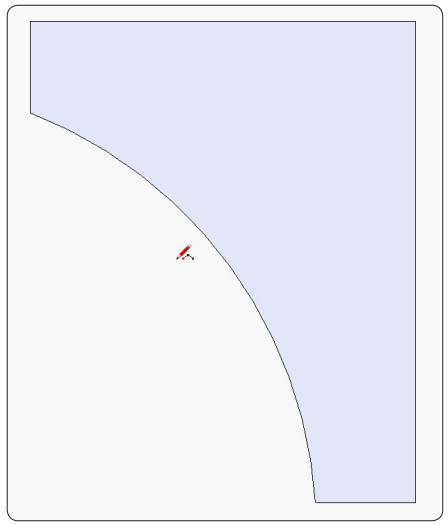


Figure 6. *Begin making the frame with a two-dimensional drawing of its profile.*

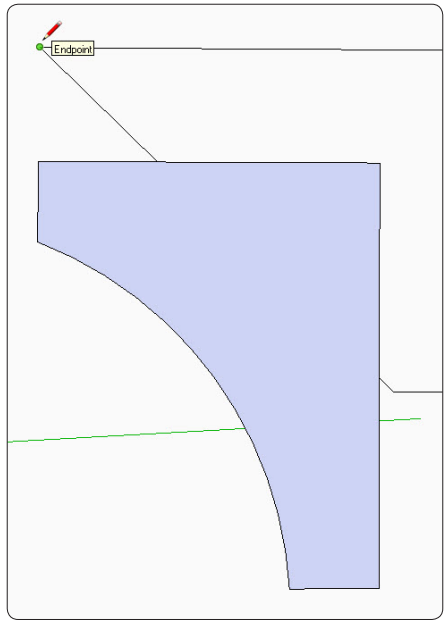


Figure 7. *Draw a path for the Follow Me Tool to use.*

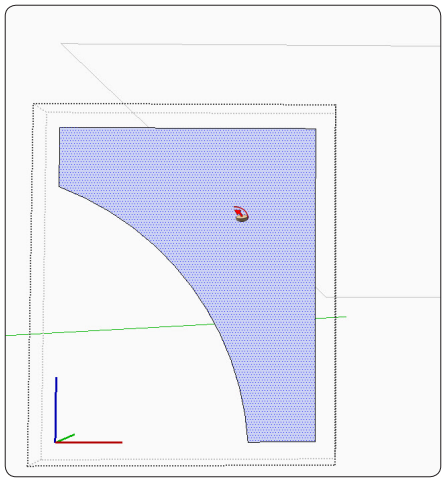


Figure 8. *To execute the extrusion, highlight the path, hover over the flat shape with the Follow Me Tool, and then click the mouse.*

Use the Select Tool to highlight the four edges of the path. Select the Follow Me Tool and use it to hover over the flat shape. Now click the Follow Me Tool on the flat-shaped face. Once the extrusion appears, delete the lines for the path. If you haven't already, make the extrusion a component.

Figure 9 shows the completed extrusion. If you wish, you can right-click on the shape and choose Reverse Faces from the pop-up menu to change the color from blue to white.

The molded frame is one integrated component. In the shop, of course, this frame would consist of four separate pieces with mitered ends. As a rule, I don't break this kind of element into its respective pieces in SketchUp; there's no advantage to doing that when it's time to build the real piece. However, there are times when you may need to show separate mitered pieces. Here's how to do that.

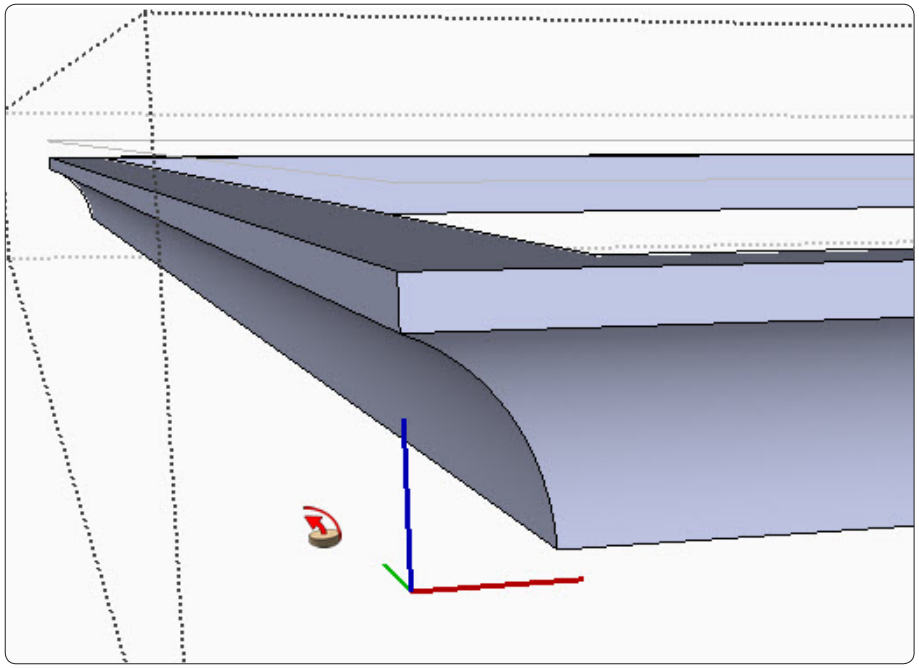


Figure 9. *The completed molding, ready to be connected to the rest of the model.*

First, use the Line Tool to draw a miter line on the top face of the joint from inside corner to outside corner, as shown in Figure 10. Do the same on the bottom face. Repeat for the remaining joints. As soon as you draw those lines, SketchUp automatically fills the miter joint with a face. You can see this face if you change the face view to X-Ray View.

Next, to break the frame into separate components, select the entire frame, right-click on the selection, and choose Explode from the pop-up menu (which essentially unmakes it as a component). Use the Select Tool to draw a left-to-right Selection Box around one of the segments, as shown in Figure 11. Right-click on the selection, choose Make Component from the pop-up menu, and name the component. Follow the same steps for an adjacent segment of the frame. Delete the remaining segments of the original frame. Now you can copy and use the Flip Along function with these two new components to make a frame with true miter joints.

How to Intersect Elements to Create Complex Shapes

In SketchUp, you can connect different shapes and find their intersections. This comes in handy for furniture design. You'd use it to make components shaped in two or more directions, such

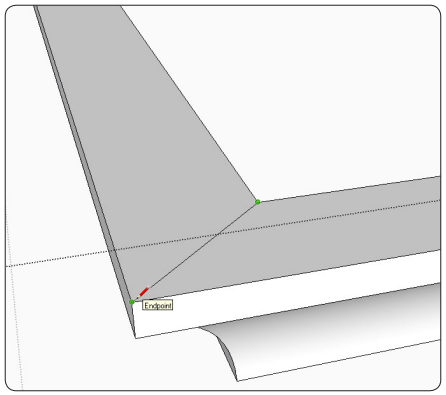


Figure 10. *Draw a miter line on the top and bottom face of the frame at each corner.*

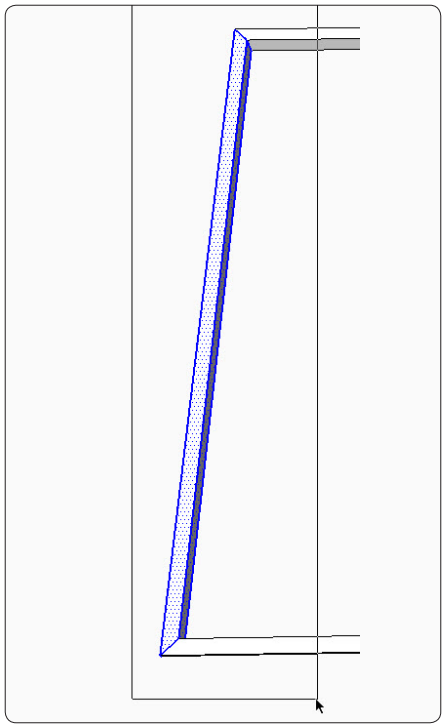


Figure 11. *To begin making the frame into separate components, isolate one side and make it a new component.*

as cabriole legs, bent crest rails, chair arms, bent back slats, sculptured seats, carvings, and knee blocks. You also use the Intersect function to connect non-orthogonal components, such as turned stretchers fitted into turned legs, splayed legs joined to a seat or tabletop, and mitered or angled joints.

The example here shows how to use the Intersect function to make the leg on the Williamsburg tea table. Basically, you intersect a shape with a copy of that shape rotated 90 degrees. Creating intersecting elements entails erasing quite a bit of waste, but underneath the waste is a clean cabriole leg.

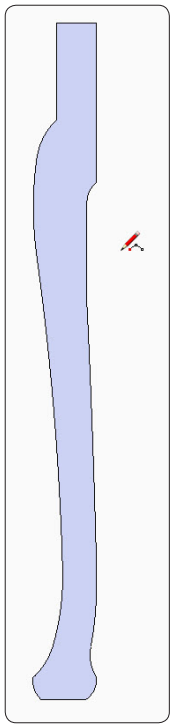


Figure 12. *Draw the profile of the cabriole shape and make it a component.*

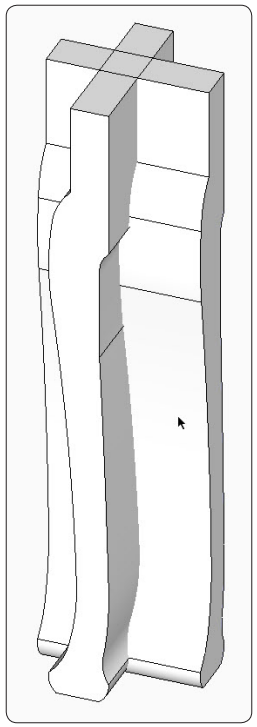


Figure 13. *Give the profile some thickness, copy and rotate it, and overlap the two elements.*

The Intersect command takes faces you've selected and creates edges at their intersections. It can create anomalies when the objects are small and the shapes sharply defined. You can often avoid such problems by scaling up the model, as described in the next section.

To make the cabriole leg, first create a face like the one shown in Figure 12. Make the shape a component.

Use the Push/Pull Tool to give the shape substantial thickness, as shown in Figure 13. Any ample thickness will do; you don't have to aim for a specific measurement.

Use the Move/Copy Tool to make a copy of the very thick element. Then use the same tool to hover over the top and rotate the copy 90 degrees. Move the rotated copy to fully converge with the first leg, as shown in Figure 13. You don't have to aim for an exact placement but make sure that the components extend well past their intersections on all sides, as shown.

Select both components, right-click, and choose Explode from the pop-up menu. Right-click on the selection again and choose Intersect Faces with Selection from the pop-up menus (Figure 14). This option works because all the edges and faces are selected and highlighted. When you want to intersect two separate components, though, choose Intersect Faces with Model.

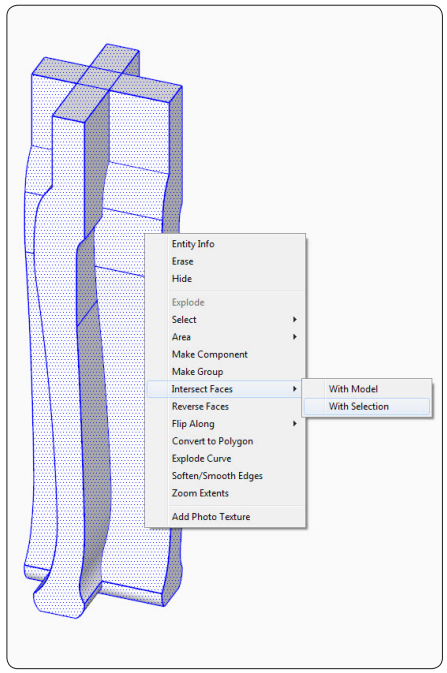


Figure 14. *Once you have selected all the elements in the components, right-click and choose Intersect Faces with Selection. This adds edges where the components overlap.*

Hard edges will appear at all the intersecting faces. The next step is to remove the waste material. You can tediously erase the waste line by line, but there's a faster way. Use the Select Tool to draw a right-to-left Selection Box over one waste area to highlight it, as shown in Figure 15. Press the Delete key. Repeat with the remaining three waste areas, resulting in a clean cabriole leg.

How to Use the Scale Tool

The Scale Tool, shown in Figure 16, is quite handy, though not often used. I find it to be perfect for enlarging small

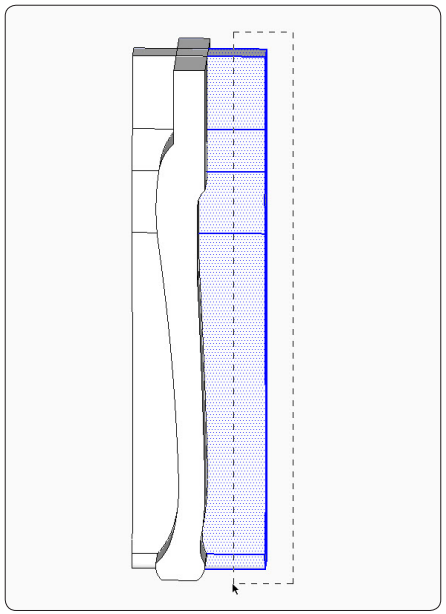


Figure 15. *To eliminate a waste area quickly, draw a right-to-left Selection Box to highlight it, then press the Delete key.*

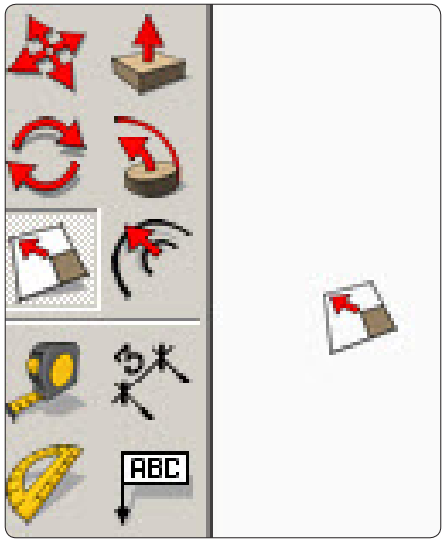


Figure 16. *The Scale Tool.*

components so they will render properly, sizing an imported scanned image, and lengthening or shortening turned legs for Windsor chairs.

Re-proportioning a model. You might think the Scale Tool would make it easy to resize furniture assemblies. Suppose, for example, you have an existing model of a table, but you would like one that's three-quarter size. You could select the model, choose the Scale Tool, grab the appropriate corner grips, type 3/4, and press the Enter key (Figure 17). Voilà! You have a three-quarter-size table, with every component reduced proportionately. In this case, however, all dimensions are reduced by a factor of one fourth. That almost always produces inappropriate changes in lumber thicknesses and joint sizes.

When you apply the Scale Tool to a model, you will see an array of 27 little green handles or grips. The ones you use determine which parts of the model will change. In Figure 17, I clicked on the longest diagonal corner grips. The grip I selected changed to red, and the dotted line appeared to connect that grip with the one diagonally opposite. A pop-up box next to the cursor tells you whether the model is being scaled uniformly, along all three axes, or only along two axes. When I move the mouse, the size of the table changes proportionately in all three dimensions.

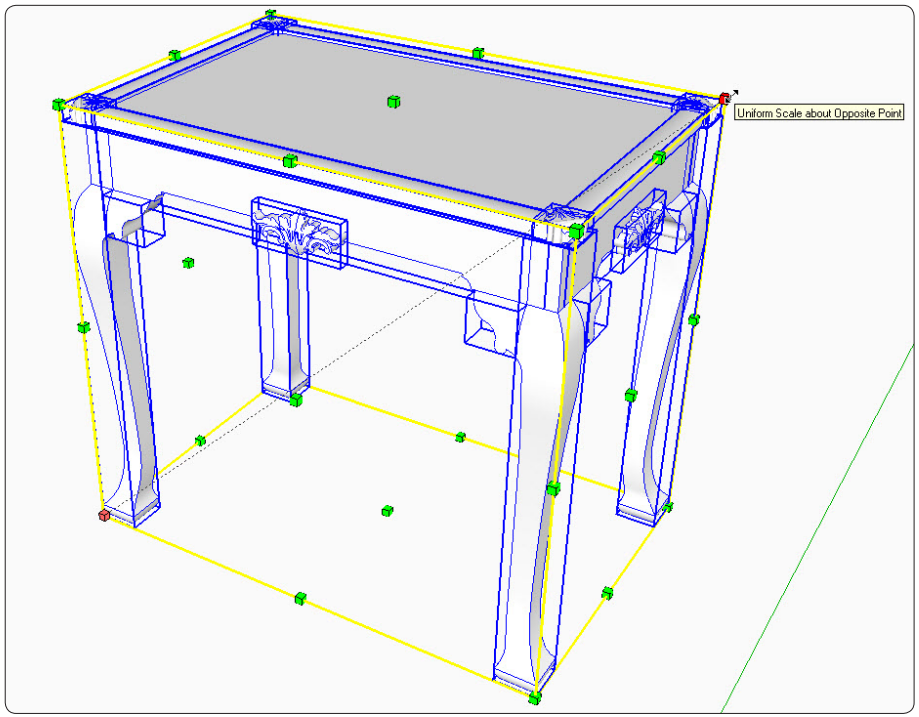


Figure 17. *When you use the Scale Tool to reduce the overall size of a design, everything—including component thicknesses and joint sizes—gets smaller.*

In this case, I haven't opened components for editing, so the original component definition of the leg, skirt, and other components does not change. I am modifying only the size of these specific instances of components. However, you can select a specific component for editing and alter its size with the Scale Tool. That will change the component definition. As a result, all copies of that component in the file will change to the new size.

Figure 18 shows the result of using the middle grips along the red axis. This changes only the dimensions in the red direction. The height and depth remain at their original values.

Figure 19 shows the result of using the middle grips along the blue axis. This changes only the dimensions in the blue direction. The width and depth remain at their original values.

Scaling up for improved modeling The Scale Tool also helps you achieve better modeling when you intersect objects. You use the tool to scale up the elements before intersecting them. If you don't, you may be left with a model containing very small facets that will not close. I typically use a 10-times scaling factor. But if the component is very small and has sharp changes in arc shapes, I may scale up by a factor of 100.

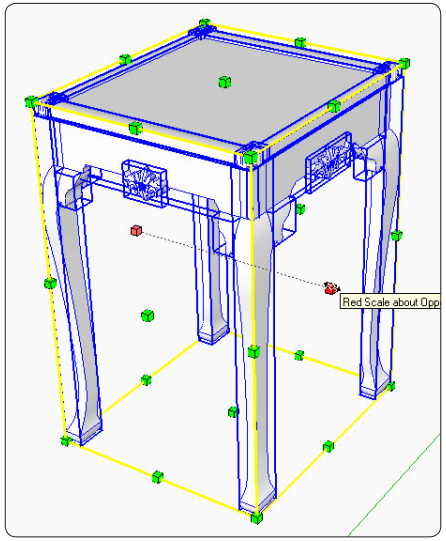


Figure 18. *The effect of changing the scale along only the red axis. The rectangular table becomes square.*

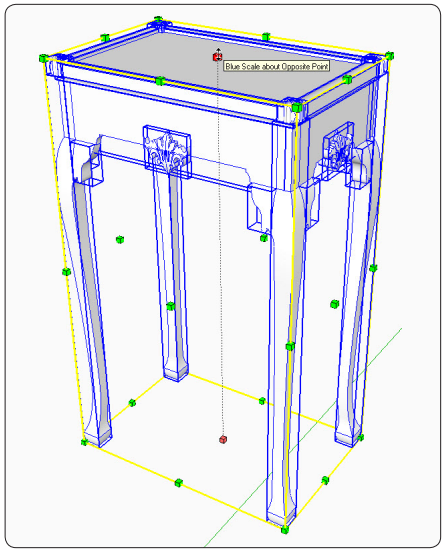


Figure 19. *The effect of changing the scale along only the blue axis. The table becomes very tall indeed.*

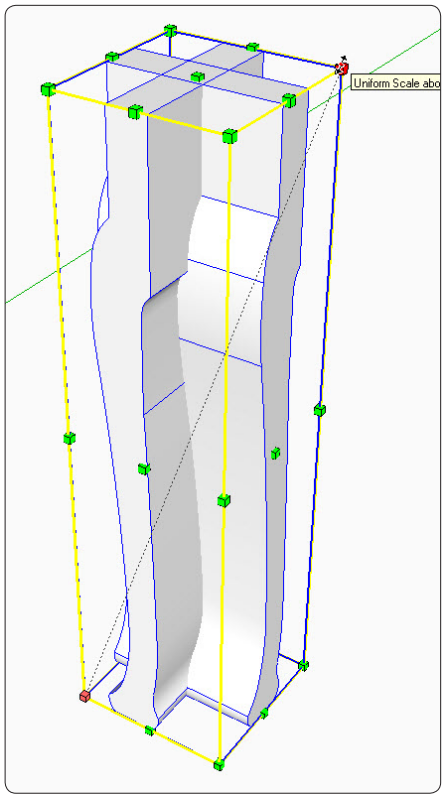


Figure 20. *Scaling up a model before you intersect elements produces a model rendered accurately and completely. Otherwise, you may be left with small facets that won't close.*

As shown in Figure 20, the cabriole-leg intersection is best done after scaling up by 10. To do that, select all the graphics to be intersected, choose the Scale Tool, click on one of the corner grips, type 10, and press the Enter key. You'll have to use the Zoom Tool to see the enlarged leg. After performing the intersection, rescale the graphics back to normal size by again selecting all the graphics, choosing the Scale Tool, and typing 0.1.

Scaling from a dimension in an image

Most of my furniture pieces begin with images that I import from my library of books and magazines. The Scale Tool allows me to scale an imported image based on any known dimension in the image.

Figure 21 shows the image from a magazine I imported and used to reproduce the tea table. In this case, the original article provided a scaled ruler on the image of the carvings. This allowed me to measure *P* (about 5⅜ in.), the length of the carved elements, for the actual table. After importing the image, I used the Tape Measure Tool to find the length of *P* as imported. I then calculated the ratio needed to scale the image so that the length of *P* in the model was equal to the length on the actual table. In this case, the ratio was 5:1.

Select the image, then select the Scale Tool and grab one of the corner handles. Yes, you have to use the corner grips or you will not get proportional change. Type the factor that makes the existing length equal to the required length. In this case, type the number 5. This scaling procedure gives a full-size image on which you can trace over the various shapes and find the sizes of key components.

How to Use the Rotate Tool

You can use the Move/Copy Tool *nearly* every time you need to rotate a component. But when you're designing furniture with splayed legs or other angled components, you need another tool. Positioning a turned leg into the seat socket at a compound angle requires use of the Rotate Tool (Figure 22). I also use the tool to accurately adjust the orientation of an imported scanned image. These images are usually askew and require slight nudges to align them with the SketchUp axes.

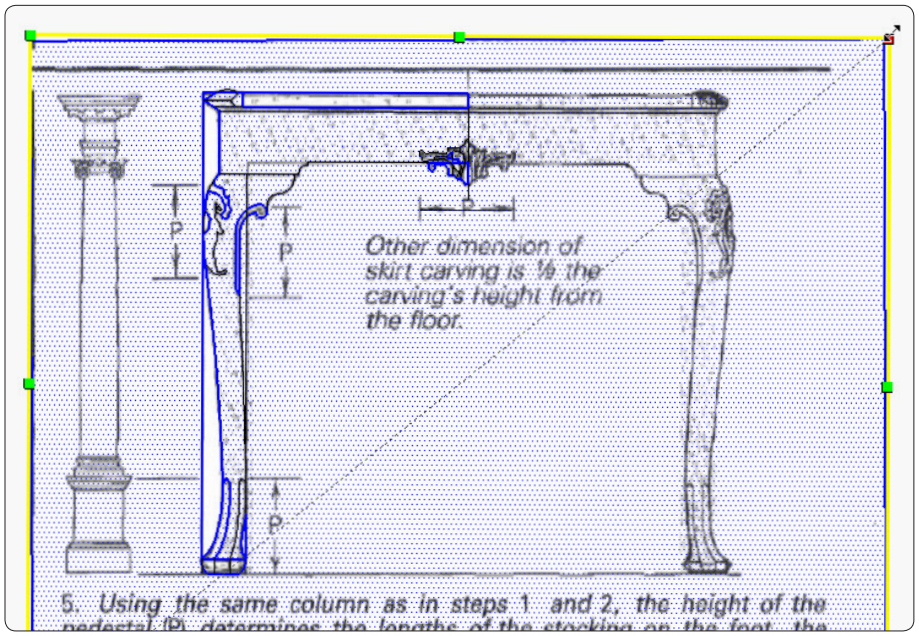


Figure 21. *With a known dimension in an imported image and a little arithmetic, you can scale the image so that the known dimension in the model is the same as it would be on the actual piece. Then you can find dimensions for other key components.*

When you select the Rotate Tool, the cursor changes to a protractor, which appears as red, green, blue, or black. The color is significant. If it is blue, for example, that signifies that the rotation will occur around the blue axis. (That is, the axis is like an axle, and the component will turn on that axle.) As you hover over faces, the color of the protractor will change based on the orientation of the face.

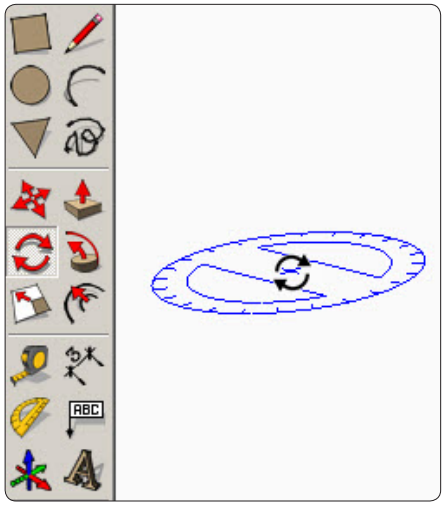


Figure 22. *The Rotate Tool.*

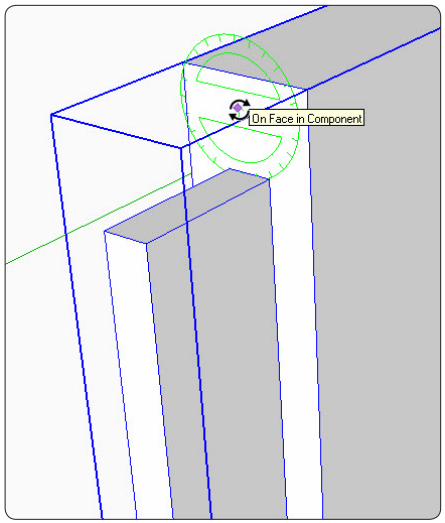


Figure 23. *The color of the Rotate Tool cursor tells you which axis the rotation will occur around. In this case, the stretcher will rotate around the green axis.*

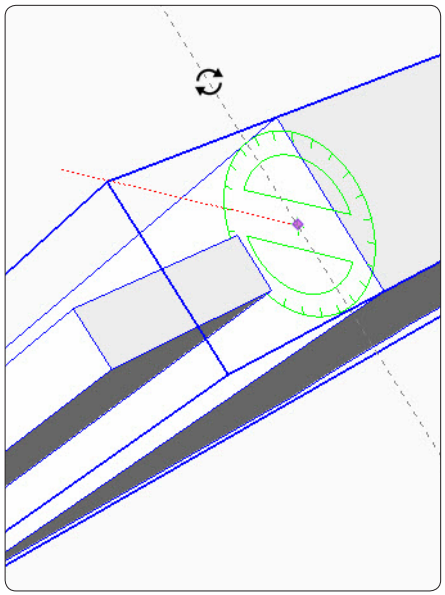


Figure 24. *The stretcher, after being rotated.*

In Figure 23, the Rotate Tool hovers over the shoulder of the tenon joint. The green color signifies that the rotation will occur around the green axis. Click the mouse and move it to find the red axis (which shows up as a red dotted line), click to begin the rotation, and click again to stop it (or type an angle and press the Enter key). Figure 24 shows the result.

When you hover the Rotate Tool over an oblique face, the cursor will be black, signifying that you are not on an axis. When the Rotate Tool hovers over empty space, the color shifts from red, green, or blue, depending on the camera view. If the camera is looking downward, the protractor will be blue. When the camera is facing a front view down the green axis, the protractor will be green.

Altering the Length or Width of Components

When designing furniture in SketchUp, you often need to adjust component sizes. You may have a fairly complete model design but have second thoughts about the overall size, proportion, or configuration. Or after a presentation to a customer, you have to make adjustments and tweaks. Even with detailed joints in place in the model, you can alter a design without too much effort.

It's very easy to modify simple components without joinery or shaped cutouts. In many cases you can do that with the Push/Pull Tool. Components complete with joints or shaped details cannot be adjusted easily by pushing and pulling. The Move/Copy Tool does the job instead. I'll use the side skirt on the Williamsburg tea table to show how that's done.

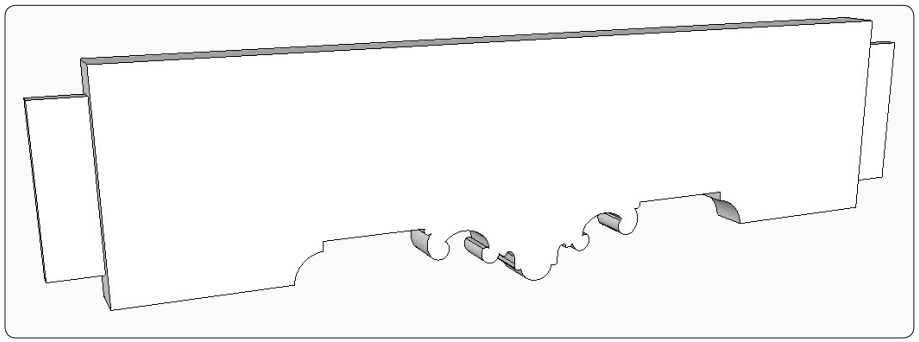


Figure 25. *Lengthening an elaborate component like this side skirt means working at the ends and leaving the middle alone.*

Assume that you want to increase the depth of the tea table by 2 in. Because there are shaped details that can't easily be changed in the center of the side piece (Figure 25) we need to extend each end by 1 in.

Right-click on the skirt and choose Edit Component from the pop-up menu. Use the Select Tool to draw a left-to-right Selection Box around the end of the skirt, including the tenon. Be sure that the box extends far enough to include all of the tenon and all of the shoulder faces and edges (Figure 26).

Select the Move/Copy Tool and click on the skirt. Tap the Left Arrow key to force movement along the green axis. Move the mouse to begin extending the length, type 1, and press the Enter key. Repeat those steps for the other end of the skirt (Figure 27). This lengthens the component but doesn't alter the proportions of the carving in its center.

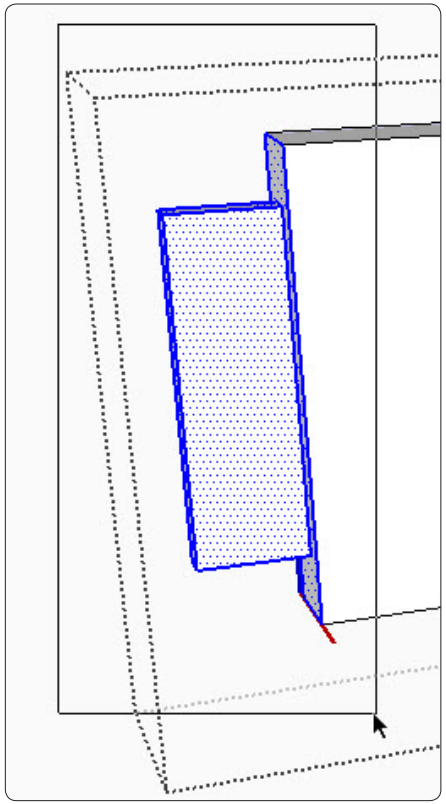


Figure 26. *To begin lengthening the skirt, select the tenon at the end.*

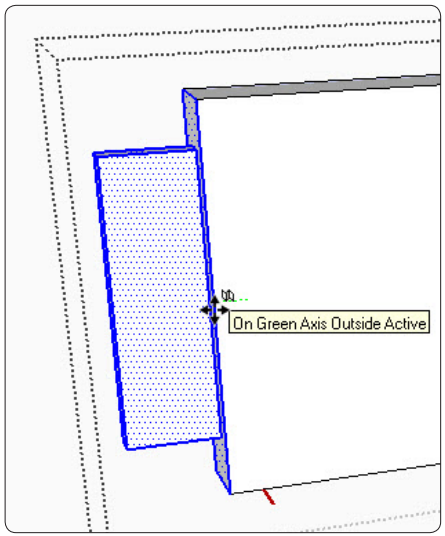


Figure 27. *Use the Move/Copy Tool to move the highlighted elements along an axis, which extends the overall length of the skirt.*

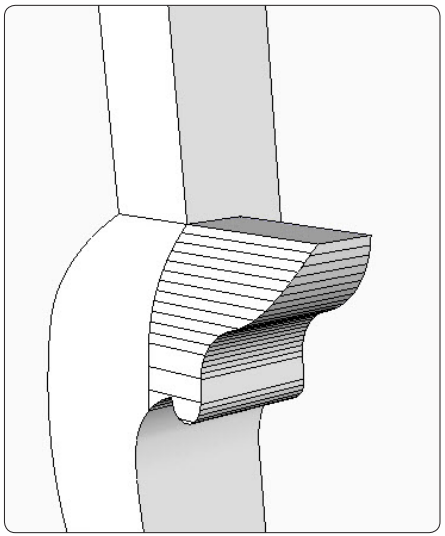


Figure 28. *The Soften/Smooth Edges function eliminates the extraneous lines on curved faces.*

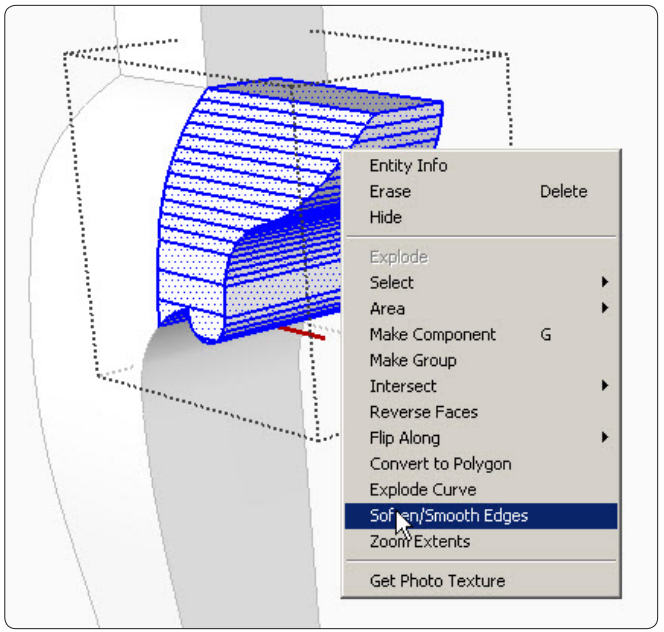


Figure 29. *With the component opened for editing, choose Soften/Smooth Edges from the pop-up menu.*

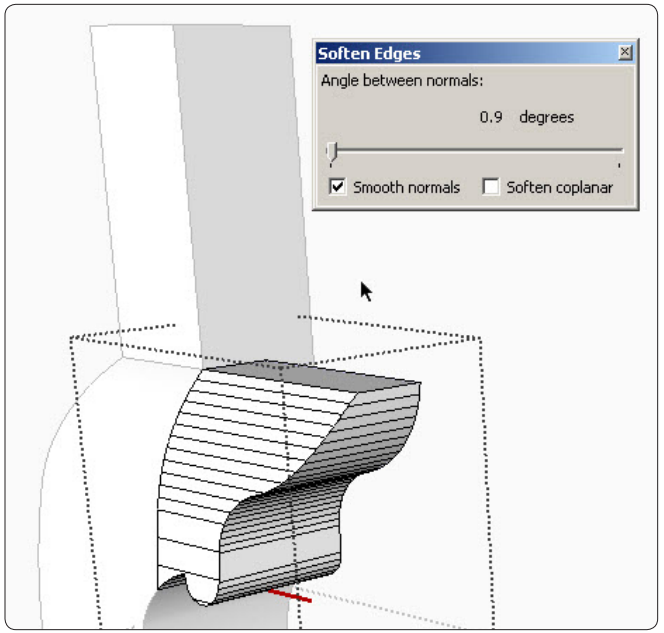


Figure 30. *The Soften Edges dialog box has a slider you use to control the degree of softening.*

Using the Move/Copy Tool to alter the length or width is wonderful for adjusting the length of a drawer side with dovetails. When you draw the Selection Box, however, include all of the graphics associated with the dovetail joints.

The Soften/Smooth Edges Function

Intersections and Follow Me commands almost always produce extraneous lines along curved surfaces. In Figure 28, the knee block on the Williamsburg tea table is shown with those extra lines.

SketchUp's Soften/Smooth Edges function will remove those lines. To use it, select the component, right-click, select Edit Component from the pop-up menu, and select all surfaces. (Or triple-click the mouse on the component.)

Right-click on the selected component and choose Soften/Smooth Edges from the pop-up menu, as shown in Figure 29.

A Soften Edges dialog box will appear, which includes a slider bar (Figure 30). Use the mouse to push the slider to the right. When the extra lines disappear, stop the slider and close the dialog box. In many cases, the lines are removed adequately at about 20 degrees, the angle between normals. Using a high number for the angle between normals tends to give the model an unacceptable appearance for my tastes. Experiment with the slider bar and observe the changes.

If you have only a few extra lines to remove after softening edges, go over them with the Eraser Tool as you hold down the Ctrl key (Option key on the Mac).

How to Use Photographs and Scanned Images

Often I see a specific piece of furniture that I would love to reproduce in the shop. When this happens, I may be visiting a museum, attending a Williamsburg event, reading a magazine, or rereading one of my many furniture books. One of my family members may see something I should build. And many ideas come from my students, who show me pictures of projects that interest them.

Whatever the inspiration, I begin a new project by researching magazines, books, and online resources. I'm looking for good images and any information about dimensions. If I'm lucky, I'll find measured front, side, and top views.

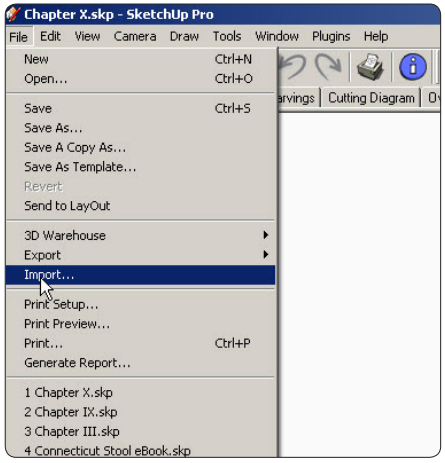


Figure 1. *The first step to importing an image.*

But most of the time, all I can find is a photograph and a caption giving overall length, width, and depth.

In any case, I try to find something I can scan and load into SketchUp. Then I can quickly get a handle on the size of the various components in the piece. I also can sort out angles and shapes that would be very hard to replicate any other way. I've used this process for all types of furniture, from picture frames to highboys and chairs.

Even if I have access to detailed, dimensioned drawings, I will still re-create the design in SketchUp. That's because I invariably find the drawings to be inaccurate and incomplete. The SketchUp modeling lets me find and fix the inaccuracies without wasting shop time or expensive wood.

How to Import and Size an Image

To illustrate the importing process, I'll use a scanned image of the Williamsburg tea table from Chapter 10.

Step 1 Click on File in the Menu Bar, then choose Import from the pop-up menu, as shown in Figure 1. That will open the dialog box shown in Figure 2. (The box looks different on the Mac, but it works the same.) In the top window, labeled "Look in," tell SketchUp what file

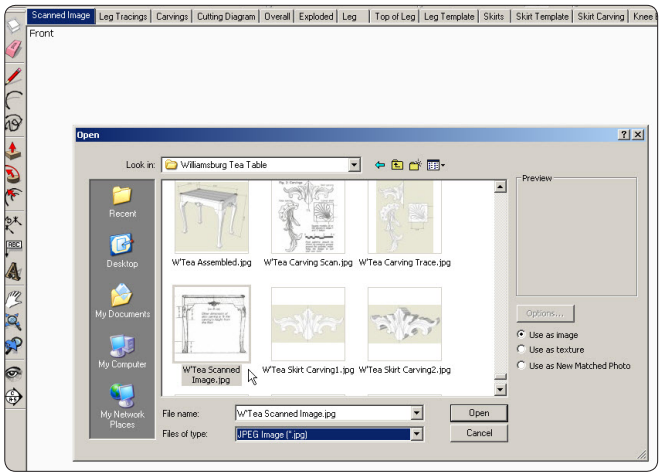


Figure 2. *Use the dialog box to find the scanned image you want.*

and folder holds the scanned image. I prefer to use the jpg format for images, but SketchUp will accept other formats, including png, psd, tif, tga, and bmp.

On the right side of the dialog box are three buttons for import choices. The first option, Use as Image, is the easiest and best for replicating furniture pieces. Later in this chapter, I'll cover the Use as New Matched Photo option. Use as Texture is covered in Chapter 14.

Orient the SketchUp screen for a front view, so the image will be positioned on the blue–red plane. Otherwise, you'll have to rotate it once it's imported.

After you have found the file containing the scanned image, highlight it in the dialog-box window, then click the Open button.

Step 2 The image will appear in SketchUp, with one corner attached to the cursor, as shown in Figure 3. Click the mouse to anchor the image at the desired location. Drag the mouse upward

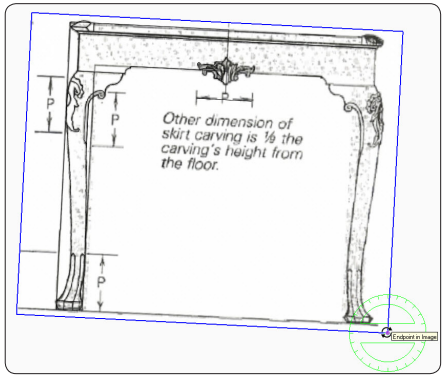


Figure 3. *The raw import, before it has been resized and repositioned.*

to enlarge the image. Click the mouse when the image is the size you want. At this point, none of the dimensions in the image is known. You will need to scale the image later, once you have it properly positioned.

Step 3 The image will likely be askew, because it's hard to place a book or magazine exactly square on the bed of a scan-

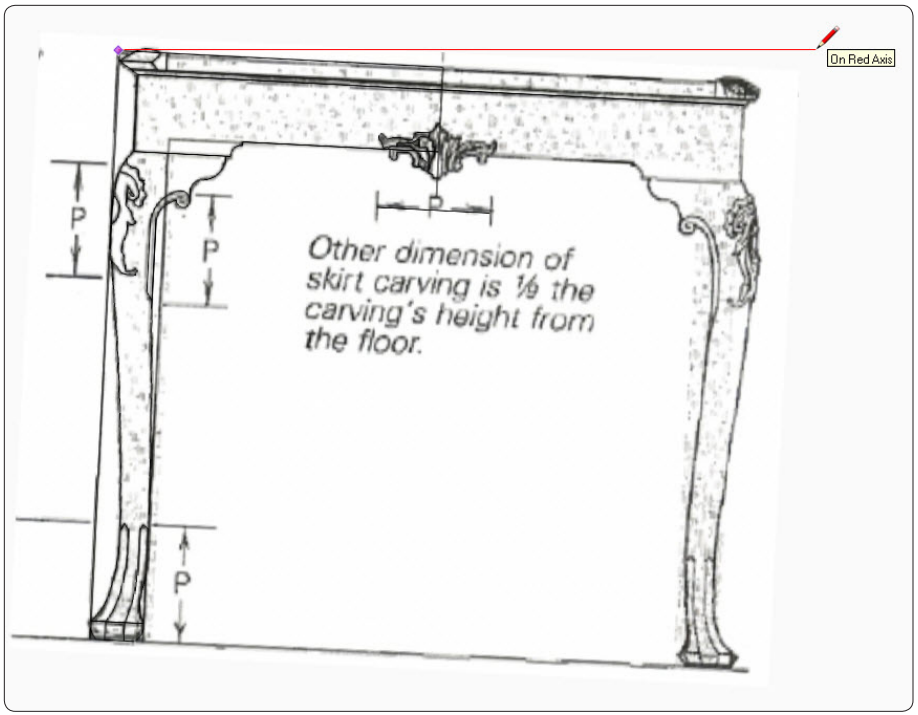


Figure 4. *To align the image, draw a reference line on-axis.*

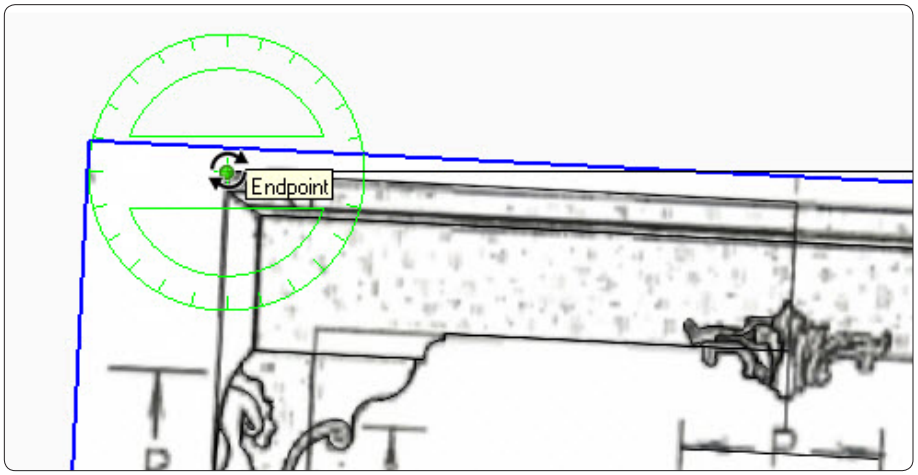


Figure 5. *Use the Rotate Tool to position the image on the reference line.*

ner. I've exaggerated the skew in Figure 3. To straighten the image and position it on-axis, you need to draw a reference line along a SketchUp axis, beginning at the end of a long edge in the image. As Figure 4 shows, I've chosen to use the top edge as the image line to adjust, so I've drawn a line along the red axis.

Select the image, then select the Rotate Tool and click on the endpoint of the line just placed (Figure 5). Move the mouse to rotate the image upward. Click the mouse on the reference line. This completes the rotation and aligns the image.

Step 4 Next, scale the image to make it full size. You need to know only one dimension in the image to accomplish the proper scaling. In this case, I know the actual length of the dimension labeled *P* in the image. It's 5¼ in.

Draw a line over the known dimension and measure it, as shown in Figure 6. In this case, it is 3⅝ in. Use the following formula to determine the scaling factor: Divide the known dimension by the size of the same dimension on the imported image. For this example, that means 5¼ divided by 3⅝. The result is 1.45.

Select the image, then select the Scale Tool and click on one of the corner grips. Type 1.45 and press Enter. This makes the image full size (Figure 7).

How to Use the Image to Rough Out Key Components

Now that the image is the proper size, begin tracing over it to get the size and shapes of the various components.

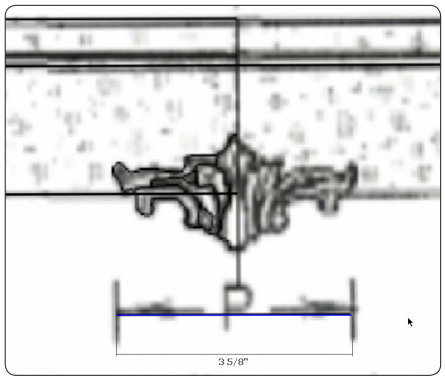


Figure 6. *To begin making the image full size, draw over a known dimension in the image and measure it.*

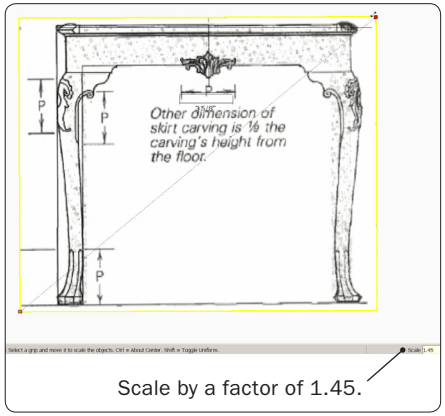


Figure 7. *To make the image full size, select it, then use the Scale Tool to enlarge it by the appropriate proportion. In this case, as the text explains, the image is scaled up by a factor of 1.45.*

Change the Face View to X-Ray. Use the Line Tool to draw lines outlining the boundary of one component. In the example, I've outlined a leg, but you could begin with a carcase front or a door. It all depends on the piece you've chosen to copy. Figure 8 shows the boundary I

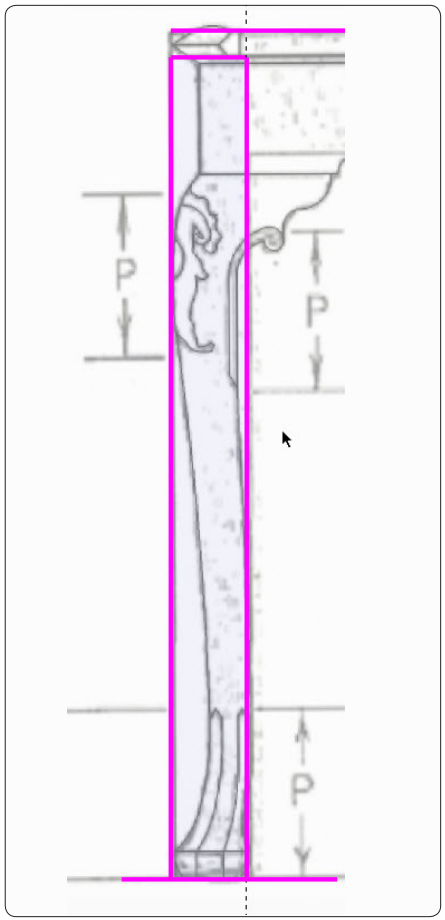


Figure 8. *Draw a rectangle that envelops a component, such as this cabriole leg.*

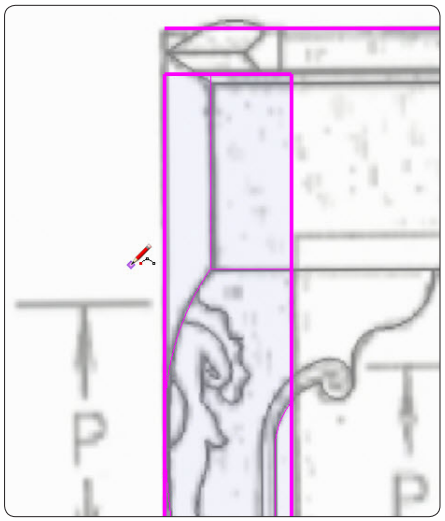


Figure 9. *Trace the shape of the component within the boundaries of the rectangle.*

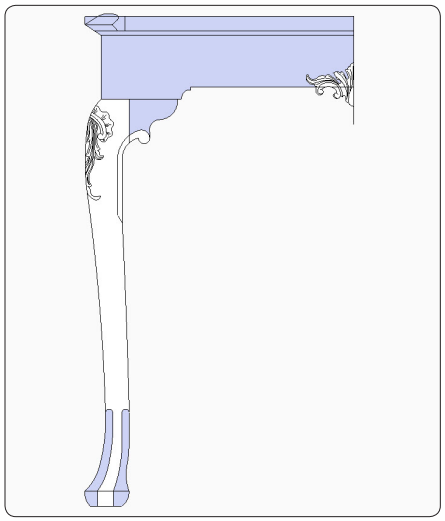


Figure 10. *All the unique components for the table have been traced.*

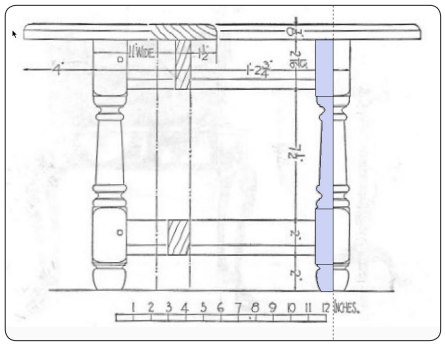


Figure 11. *To duplicate turnings from an imported image, you need to trace only half the turning. The Follow Me Tool will use that face to create the 3D shape.*

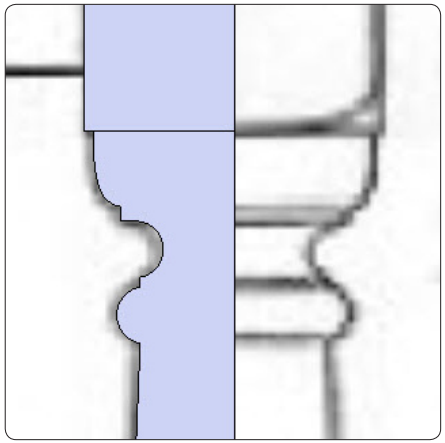


Figure 12. *Zoom in close when you trace over fine details.*

traced; I've emphasized the lines by making them thicker and magenta.

As soon as you complete the rectangle shape, SketchUp will fill it with a face. But by using X-Ray View, you can still see the image shapes through the face.

Trace over the specific shape of the component—in this case, the cabriole shape of the leg—using the Line and Arc Tools, as shown in Figure 9. (You can also use a popular B-Spline plug-in to make these complex shapes.)

To make a complex shape like the cabriole leg, use the Arc Tool to make multiple interconnected arc segments. With practice, you can place the arcs fairly quickly. And SketchUp makes it easy by showing tangency in a cyan color. When starting a new arc segment from the end of a previous one, look for the cyan color to ensure you have a good tangent connection.

Figure 10 shows the final result of my tracing. For clarity, I turned off X-Ray View. I've traced all the unique components: the top, the skirt, the leg, and the knee block. In this case, I also traced the carvings, which I used to create full-size templates to lay out the carvings in the shop. I'd do the same with molding profiles and other seemingly small details. In short, if I think I can speed up the design process by tracing a detail from the image, that's what I do.

This trace-over is only a plane of many faces that have no thickness. Still, the faces give the size and shape of most of the components. And you can quickly turn the shapes into 3D components.

How to Use an Image to Create Turnings

Figure 11 shows a scanned image for the Connecticut stool introduced in Chapter 3. The drawing, a small image from a book, provides a "ruler," which I used to align and scale the image. And I used the dimensions in the drawing to check the scaling. The blue face shows what I traced. Note that I went over only half of the leg profile; that's all I need to make a path for the Follow Me Tool, which I use to create a 3D turning. (The Follow Me Tool is explained in Chapter 9; the specific technique for making a turned leg that has square pommels at the ends is covered in Chapter 13.)

When you try to trace over small, intricate details, such as the beads and coves in the stool leg, zoom in close to the

area being traced, as shown in Figure 12. You need that intimate view for good results. Figure 13 shows the final leg.

How to Use the Photo-Matching Function

Tracing over scanned images to make 2D shapes and faces is most effective when you have access to drawings or orthographic front, side, or top views.

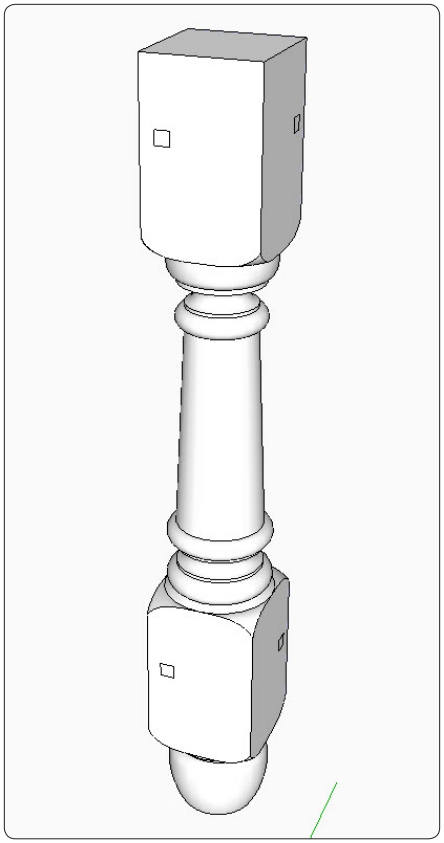


Figure 13. *The final 3D leg, created from the traced face with the Follow Me Tool; see Chapters 9 and 13 for the technique.*

SketchUp also has a way to use photographs to obtain 3D dimensions and shapes. It is called Photo-Matching. It can work when you have only a photo.

Photo-Matching has its limitations. For one, the object in the photo needs to be rectilinear, or at least have a pair of surfaces at right angles to each other. That means Photo-Matching isn't very useful for modeling chairs or other angled and shaped pieces. For another, some photographs will just not work with Photo-Matching. This function is designed to work off of the focal-point center of a photo. The more off-center that point, the more likely the alignment will be incorrect. So whether you take the photo or scan it from a book or magazine, don't crop the image lest you markedly change the center point. I've occasionally had trouble using Photo-Matching with pictures scanned from books.

For me, Photo-Matching isn't as reliable as the Use as Image process, but I use it when all I have is a photo.

Here's how to make it work. I'll illustrate the process with a photo of a Shaker blanket chest.

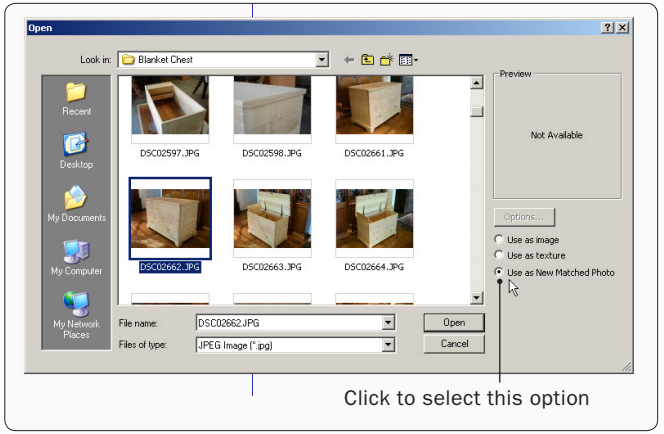


Figure 14. *To model from a photograph, choose the image you want and select the option shown.*

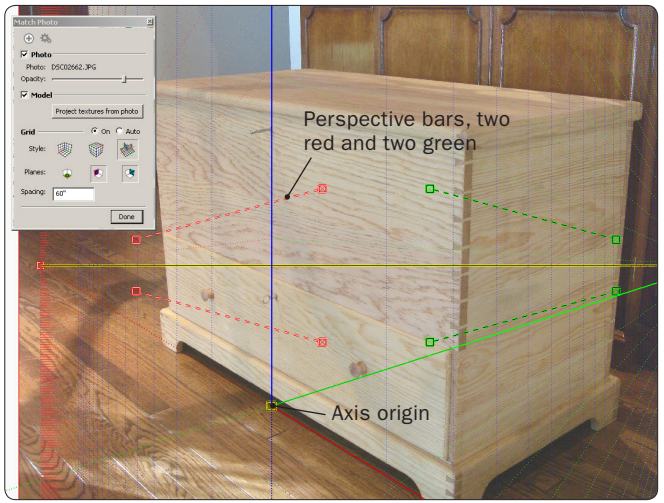


Figure 15. *What you see when you open a Matched Photo. The perspective bars allow you to align the image with a SketchUp axis.*

Step 1 Open a new SketchUp file. Click on File in the Menu Bar and select Import. When the dialog box appears, locate the folder containing the photo you want to use, choose the Use a New Matched Photo option, then click Open (Figure 14).

The photo will appear in the SketchUp screen, along with a seemingly odd collection of colored guide lines known as perspective bars and a new dialog box, as shown in Figure 15. In the dialog box, make sure that the Style is set to Outside, the third icon in the row. It means that the photo has been taken from outside the object.

Step 2 Line up the dotted perspective bars with edges in the photo. Begin by aligning the green perspective bars with two parallel edges. Use the Select Tool to drag the ends of these bars to the corners of the object in the photo. Position the bars in a direction that agrees with your preferred axis orientation. I usually face my furniture models on the red–blue axis, so the green perspective bars are aligned front to back (Figure 16). Similarly, line

up two red perspective bars on edges that align with the red axis.

Next, drag the axis origin (the little square where the three axes come together) to a corner where the object touches the floor. Check the arrangement of the blue, green, and red axes. You want the solid blue line going upward, the red solid line to the left or right of the origin, and the solid green axis moving toward the rear from the origin. All three should line up with the edges of the object (Figure 16). If these axes are not aligned with the blanket chest edges, the Photo Match will not work.

When you've finished aligning the perspective bars and the axis origin, click Done in the dialog box. The colored lines and grips will vanish, leaving only the imported photo.

Step 3 Use the Line Tool to begin drawing in faces for various components in the piece. For the blanket chest, I can draw faces for the side, top, front, drawer, and base, and I can use the Push/Pull Tool to set the thickness of the top and base.

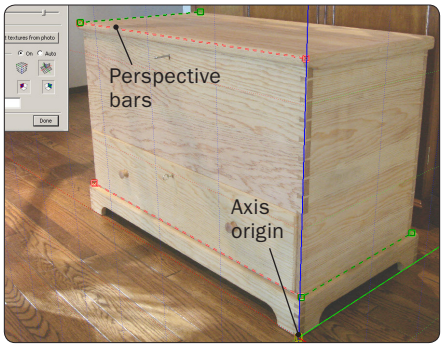


Figure 16. *Align the perspective bars with edges of the object in the photo. Here, the green bars follow the green axis front to back, while the red bars follow the red axis left to right.*

Use the Line, Arc, Circle, and Push/Pull Tools to trace over the photograph edges. Use the arrow keys to help stay on axis as you trace. As you create faces, you obscure the photograph. Change the Face View to X-Ray View to see the underlying image.

Step 4 Periodically orbit the image so that the photograph disappears (see sidebar). Look over your graphics to check that the faces and edges are oriented properly. Use the mouse to zoom in close to be sure you've placed lines accurately (Figure 17).

Step 5 Rough-in as many details as you need. In the blanket chest example, I've drawn the drawer front, placed the knobs, and used the Arc Tool to create the cutout in the base. This will not be sufficiently accurate for the final shape, but it will help locate the final cutout (Figure 17).

Step 6 You can now scale the resulting faces and edges to a known dimension (or to a dimension that represents your best guess). Rather than use the Scale Tool, you can use the Tape Measure Tool to conveniently resize your drawing.

Choose the Tape Measure Tool and tap the Ctrl key (Option on Mac) to place the tool into its measuring mode. Click on one edge of the component whose

What Happened to My Photo?!

If you use the Orbit Tool while tracing over a photo, the photograph will disappear. All you will see are the edges and faces you created, as in Figure A. To bring the photograph back, click on the Scene Tab just below the toolbar, as shown in Figure B.

When the photograph was imported, SketchUp automatically created the tab, using the photo's file name. In case you need to return to Photo Match editing, right-click on the Scene Tab and select Edit Matched Photo from the pop-up menu. All the colored lines, grips, and dialog box will reappear. I will cover the use of Scenes in more detail in Chapter 15.

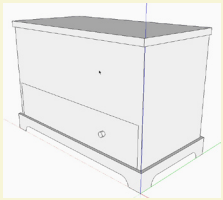


Figure A. *When you use the Orbit Tool, the underlying photo vanishes, leaving only the faces you have drawn.*

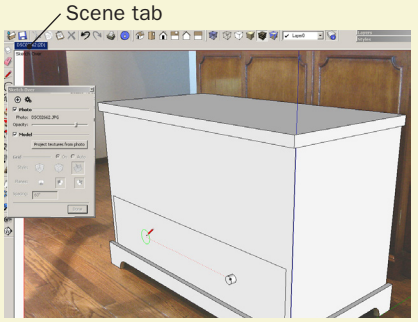


Figure B. *SketchUp automatically creates a Scene Tab when you import a photo. If you use the Orbit Tool and lose the photo, click on the Scene Tab to restore it.*

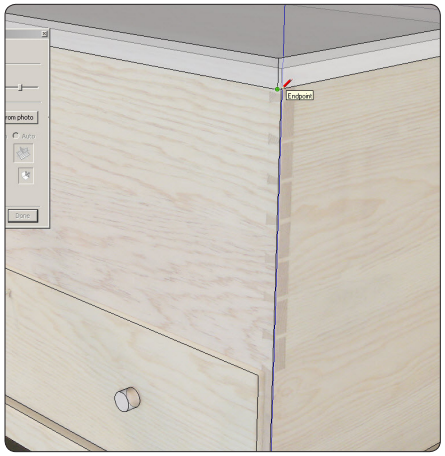


Figure 17. *Trace as many details as you need. Left: I've zoomed in to trace the basic shape and position of the drawer knobs. Right: I've roughed-in the curve on the base.*

size you know, then click on the other end of the piece (Figure 20). For the blanket chest, the dimension came from the book with the photo of the chest.

The measurement will appear in the Measurements Box (in this case it's a whopping 204 7⁄16 in.)

The actual length of the piece is 40 in. Type 40, which will appear in the Measurements Box. A small dialog box will also appear, asking if you want to resize the model. Click the Yes button. When you do that, the entire model is resized proportionately.

The Photo-Match process has sized all the pieces you drew. For the blanket chest, we now know its approximate depth and height, plus the height of the base, cutout dimensions, thickness of the top, and the approximate size of the drawer. But if you compare the dimensions in Figures 21 and 22, there are minor discrepancies between the Photo-Match image and the final model that I used to construct the blanket chest. You should expect such discrepancies, which have several possible causes: the quality of the photograph, the positioning of the perspective bars, and the precision of the tracing. However, it's easy to compensate for the discrepancies and make adjustments as you develop the actual model.

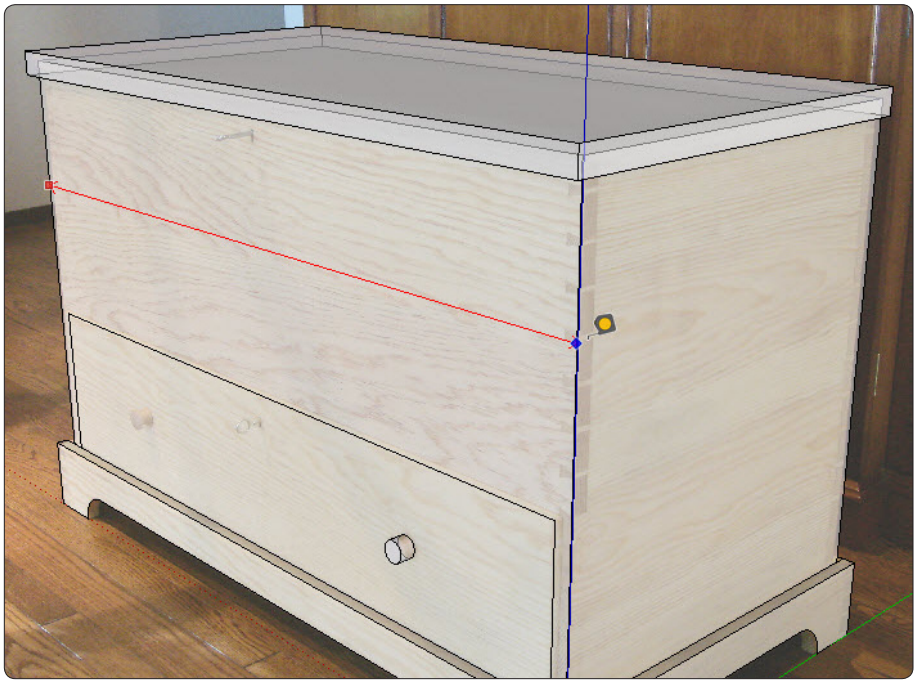


Figure 20. *Use the Tape Measure Tool to check the length of a piece whose actual size you know. In this case, it's the front piece of the blanket chest.*

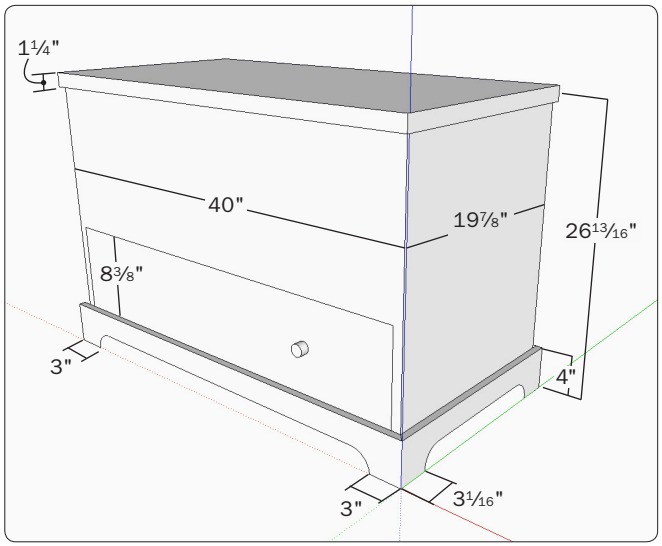


Figure 21. *The resized model, with the resulting new key dimensions.*

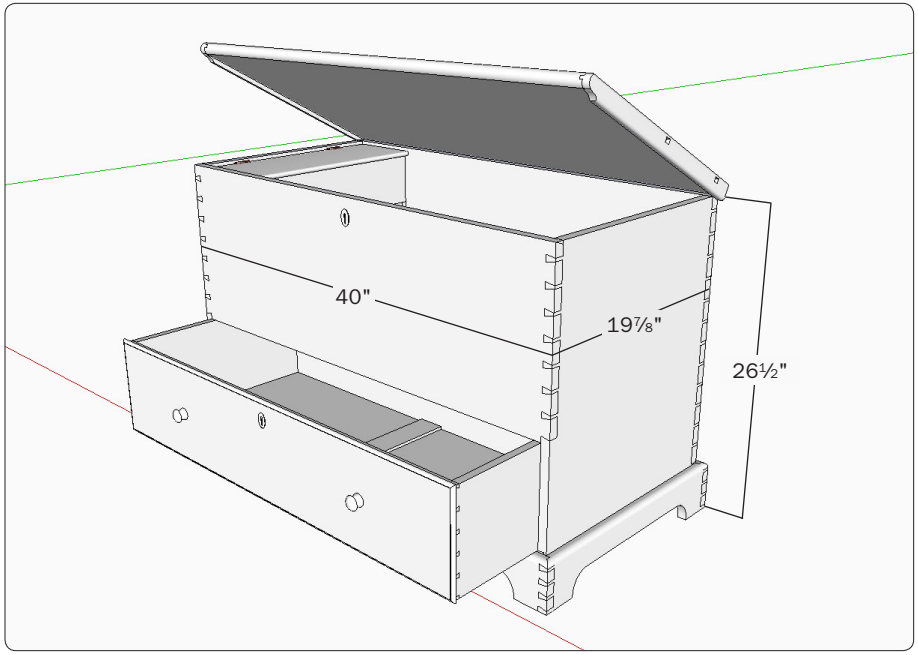


Figure 22. *The final model, used to construct the blanket chest in the Matched Photo. Some dimensions changed very slightly in the course of developing the model.*

Advanced Modeling Techniques

In the shop, building a chair requires different tools and strategies than a chest of drawers does. So it is with SketchUp. Modeling furniture with curved or turned components or pieces joined at complex angles requires different tools and techniques.

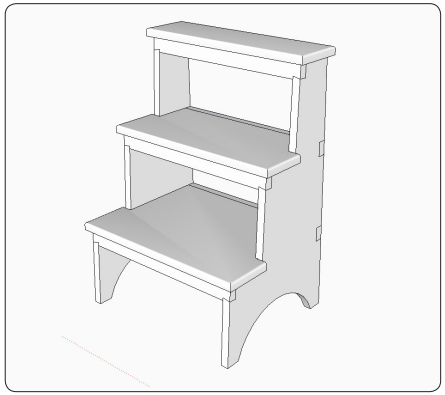


Figure 1. *Shaker step stool.*

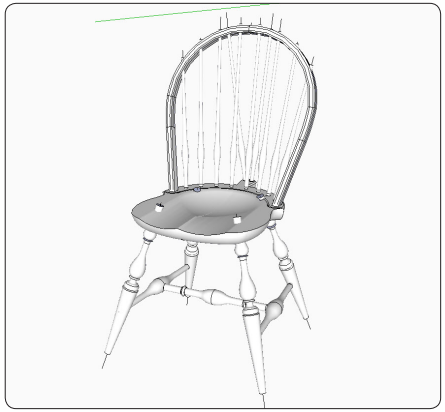


Figure 2. *Windsor bowback chair.*

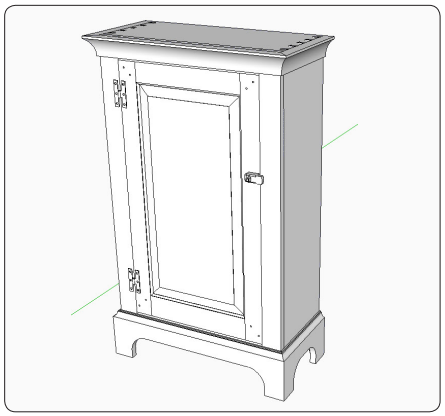


Figure 3. *Colonial cupboard.*

I've chosen three pieces, each of which illustrates a different set of advanced techniques:

- A Shaker step stool shows how to handle angled components and joints (Figure 1).
- A Windsor chair features turnings set at various angles as well as a bent bow for the back (Figure 2).
- A small colonial cupboard, an otherwise straightforward piece, has a mitered thumbnail molding on its door frame (Figure 3).

The steps for modeling each piece represent what works best for me, not the only way to tackle a project. Here, too, SketchUp mirrors experiences in the shop. Just as some woodworkers maximize their use of power tools while others mainly use hand tools to build the same piece, so do SketchUp users develop their own ways of working.

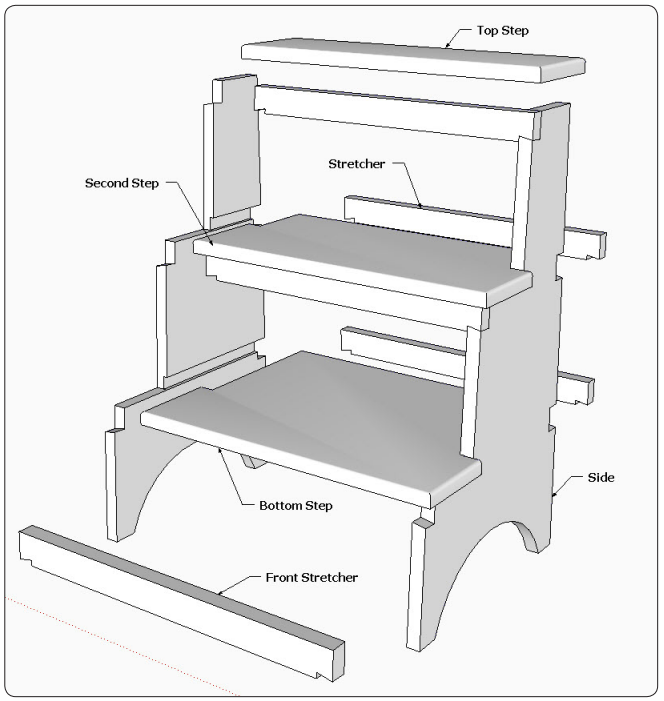


Figure 4. *The step stool has only six unique components. Shaping the front stretcher illustrates how to handle pieces at an angle.*

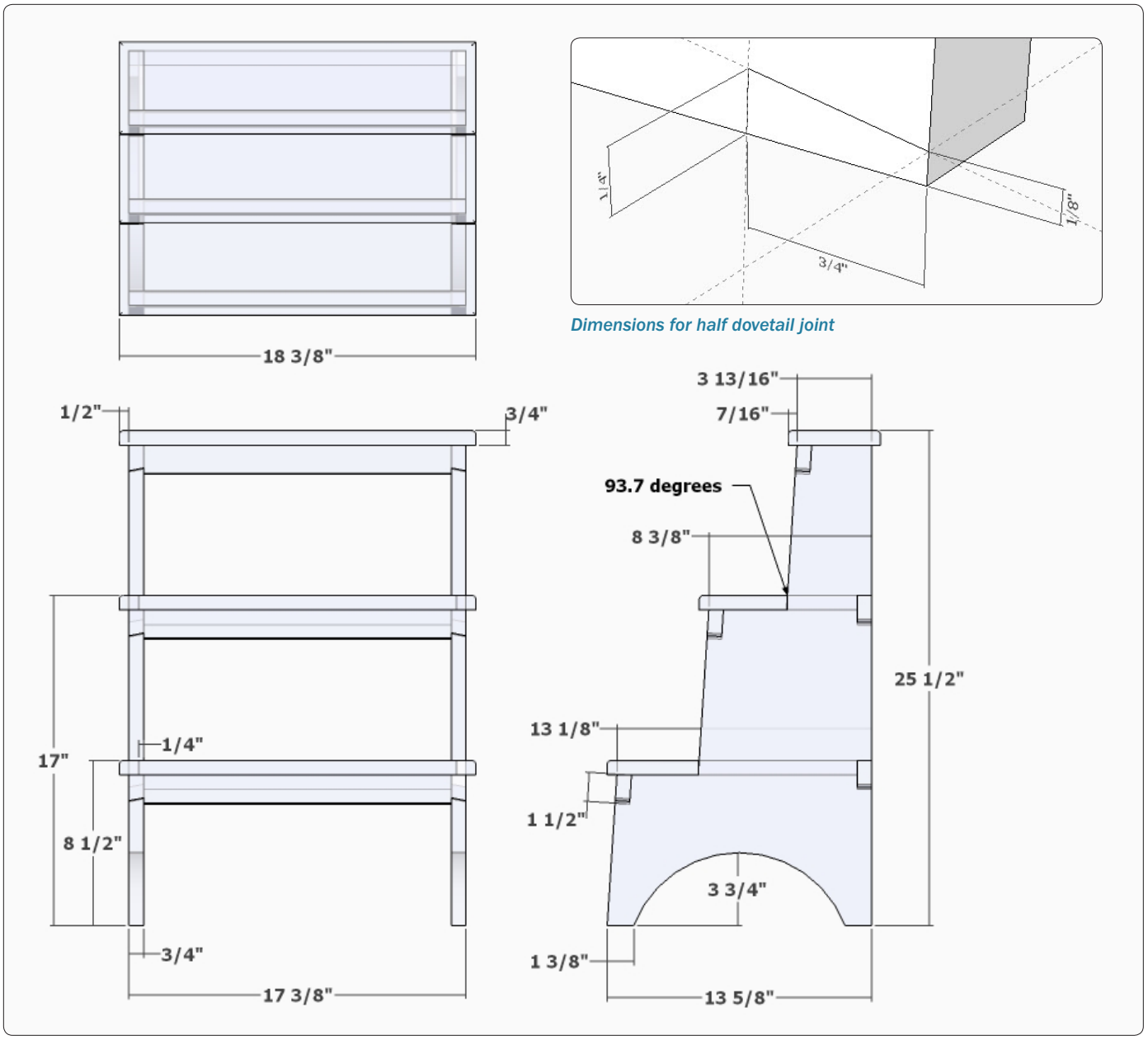
By now you should be comfortable using the SketchUp tools and should be familiar with basic modeling techniques. So, for the three projects in this chapter, I won't detail each step in their construction.

A Shaker Step Stool

The step stool shown in Figure 4, adapted from *Shop Drawings of Shaker Furniture and Woodenware,* by Ejner Handberg, makes a good practice piece for SketchUp. The stool has only six unique components, all made from straight planks of wood, but it also has some complexities. The risers for the steps are cut at an angle, which means that the front stretchers must be rotated to fit. The stretchers have half-dovetail joints, which require some SketchUp "planing" to fit properly in the sides.

Figure 5 is an orthographic, dimensioned view of the stool. Print it out and keep it at hand as you build the model.

Step 1 Use the Line Tool to draw a rectangular face for the side piece. Use the Tape Measure Tool to place horizontal guide lines for the locations of the steps and vertical guide lines to indicate the cutout locations. Then use the Protractor Tool to place angled guide lines for the risers. Figure 5 gives the angle to use, and Figure 6 shows the side with the guide lines in place.



Dimensions for half dovetail joint

Figure 5. *Side, front, and top views of the Shaker step stool.*

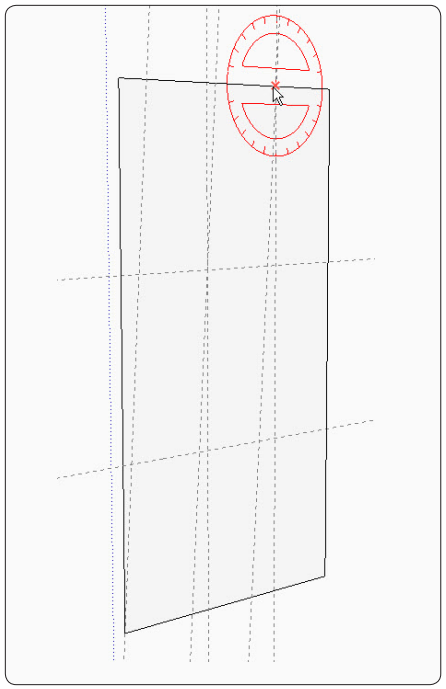


Figure 6. *Draw a rectangle for the side, then place guide lines to define the shape of the steps and the arced cutout at the base.*

Step 2 Use the Line Tool to trace over the guide lines for the treads and risers in the side piece (Figure 7).

Step 3 Use the Eraser Tool to delete the waste, then use the Push/Pull Tool to give the side the proper thickness (Figure 8). If you haven't already done so, make this piece a component named Side.

Step 4 Copy the side and move the copy. As Figure 5 shows, the outside-to-outside distance is 17⅜ in. Use the Flip Along function on the copy to orient it properly.

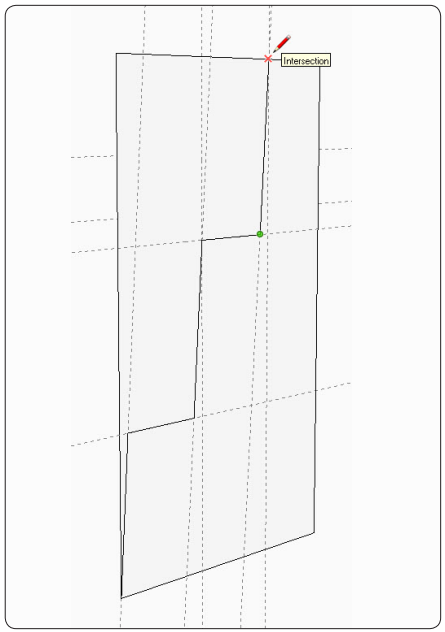


Figure 7. *Trace over the guidelines to make the shape of the side.*

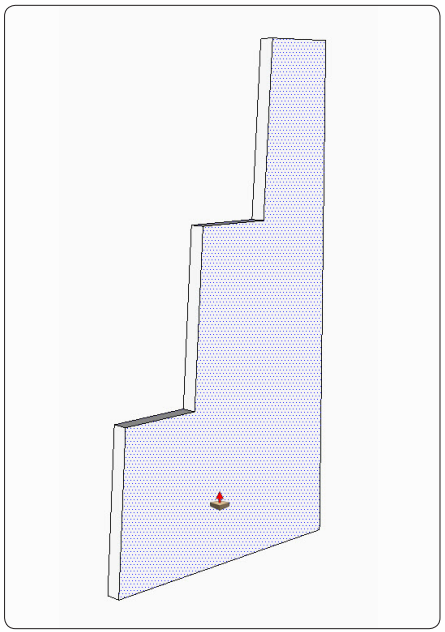


Figure 8. *Erase the waste, then give the component the proper thickness.*

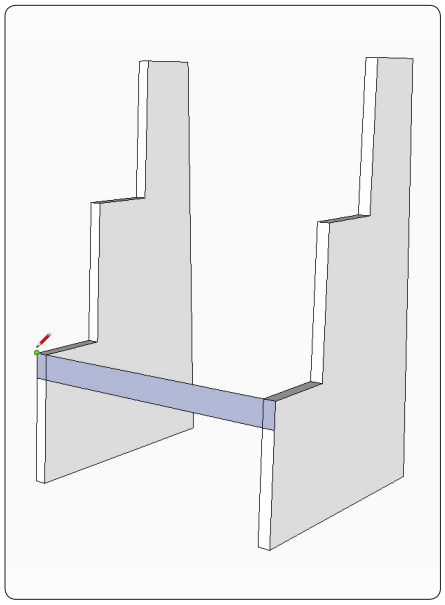


Figure 9. *With the side component copied and placed, draw a rectangle over an angled riser to rough-in the front stretcher.*

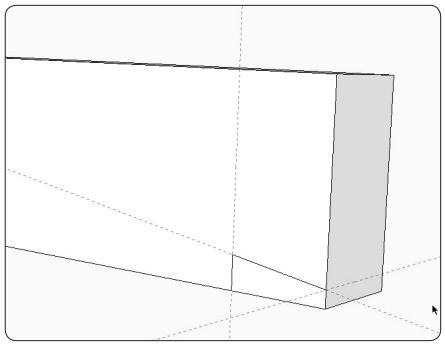


Figure 10. *Draw the half dovetail and remove the waste.*

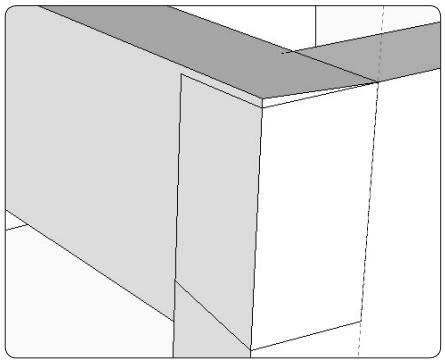


Figure 11. *Outline the tiny triangular sliver at the top of the stretcher.*

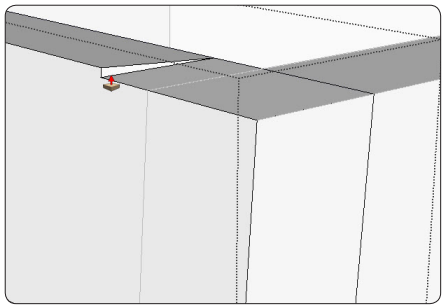


Figure 12. *Use the Push/Pull Tool to "plane" away that sliver of waste, so that the top of the stretcher is flush with the tread on the side component.*

Step 5 Use the Line Tool to draw in a rectangle for the front stretcher (Figure 9). Since it is drawn in place, it will already be at the same angle as the riser on the side. Make the stretcher face a component. Use the Push/Pull Tool to give it the proper thickness.

Step 6 Copy the stretcher and move it away from the side components. Use the Tape Measure and Protractor Tools to place guide lines to lay out the half-dovetail on one end, as shown in Figure 10. Move the Tape Measure icon along the edge of the stretcher component to be sure the guide lines follow the slant of the component rather than an axis. Use the Line Tool to draw over the guide lines, then use the Push/Pull Tool to push out the waste piece. As shown in Chapter 6, copy this end of the stretcher, flip it, and attach it to the other end of the stretcher to make the other half-dovetail. Delete the copy of the stretcher component.

Step 6 Since the stretcher component is rectangular in cross-section, it needs to be moved slightly so that its back edge is flush with the top edge of the step. Place a guide line on the side component to help nudge the corner of the stretcher up to the edge of the side, using the Move/Copy Tool. As Figure 11 shows, there is a small triangular sliver on the stretcher that needs to be planed off. Select the stretcher component for editing, then use the Line Tool to draw a line across the end of the stretcher. Use the edge of the step as a guide. Use the Push/Pull Tool to eliminate the sliver, as shown in Figure 12.

Step 8 With the stretcher in place, open the side component for editing. Use the Line Tool to draw the half dovetail joint on the face of the front edge. Use the Push/Pull Tool to push out the dovetail socket in the side (Figure 13).

Step 9 As shown in Figure 14, I've pulled the stretcher away from the side to show the remaining sliver that must be removed from the side component.

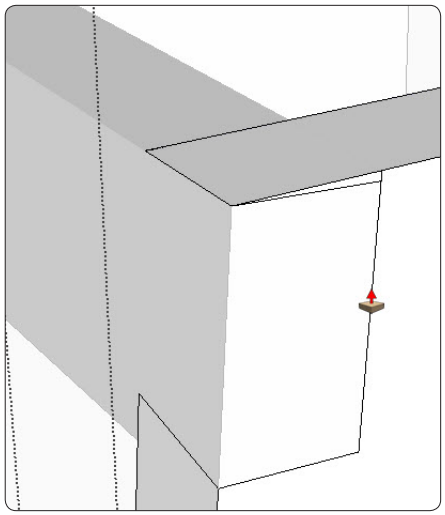


Figure 13. *Use the dovetail shape on the stretcher to draw the other half of the joint on the side, then use the Push/Pull Tool to remove the waste.*

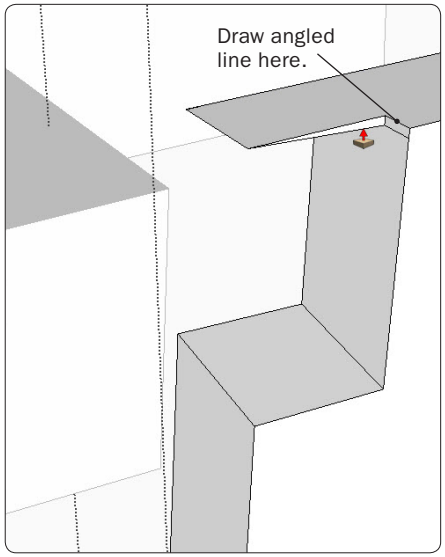


Figure 14. *Use the Push/Pull Tool to remove one last sliver of waste to complete the dovetail joint.*

Draw a short angled line on the side, then use the Push/Pull Tool to remove the triangular wedge.

Step 10 Copy the front stretcher component twice and place the copies on the other step locations. Repeat the process of cutting the dovetail sockets in the other two locations on the side component.

Step 11 Place guide lines to mark the ¾-in. wide dadoes in the side component, which hold the middle and bottom steps. Draw a line over those guide lines, then use the Push/Pull Tool to create ¼-in.-deep dadoes (Figure 15).

Step 12 Repeat Steps 5 through 9 to create the back stretchers, make half-dovetails on their ends, and cut dovetail sockets in the rear of the side component. Refer to Figure 5 for the necessary dimensions. As Figure 16 shows, the top of the back stretchers align with the top of the dadoes in the sides. Making the rear stretchers is simpler because they are aligned with the axes and not at an angle. There are no small triangular slivers to eliminate.

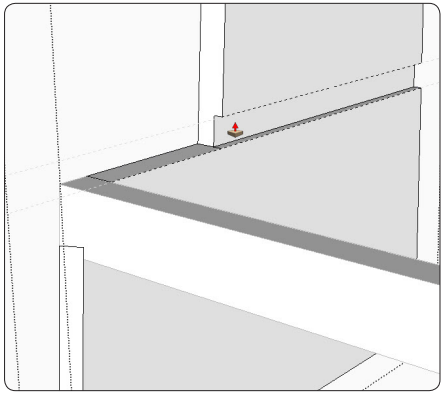


Figure 15. *Create dadoes in the sides to hold the middle and bottom steps.*

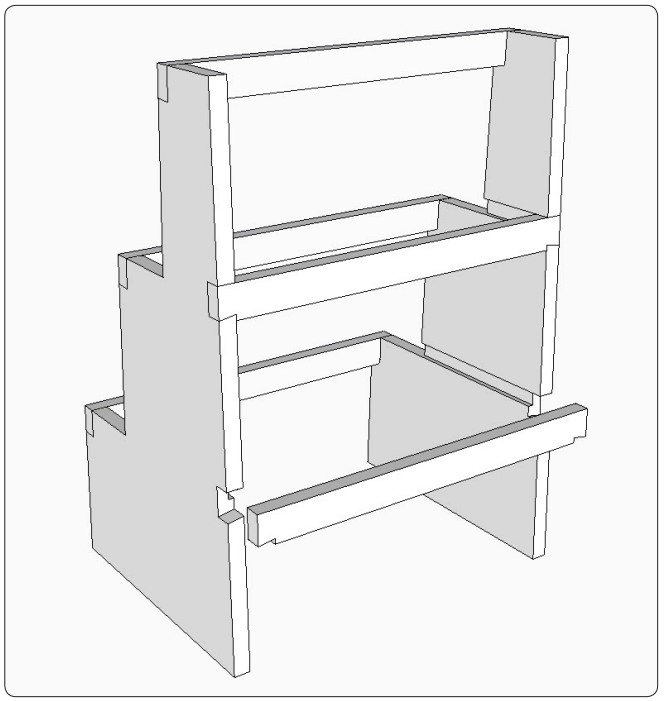


Figure 16. *Make the back stretchers and the half-dovetail joints just as you did for the front stretchers. This time, the work is simpler because everything is on-axis.*

Step 13 Use the Line Tool to trace around the perimeter shape of the middle step. As shown in Figure 17, this face is roughly T-shaped, following the outside of the sides and the front stretcher, then jogging in at each side to run along the bottom of the dadoes and finally along the back stretcher. Make the step face a component.

Step 14 Use the Push/Pull Tool to give the step its proper thickness. Use the Push/Pull Tool again to pull the edges

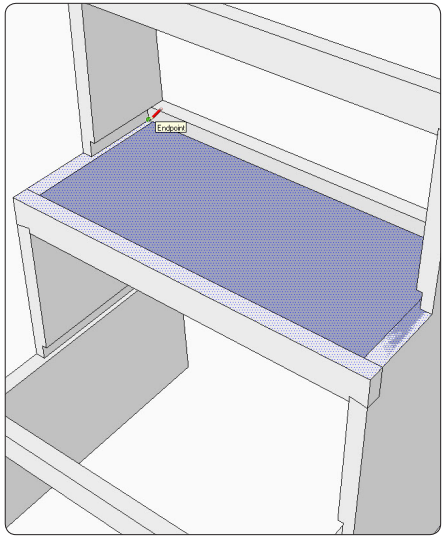


Figure 17. *Draw the face of the middle step.*

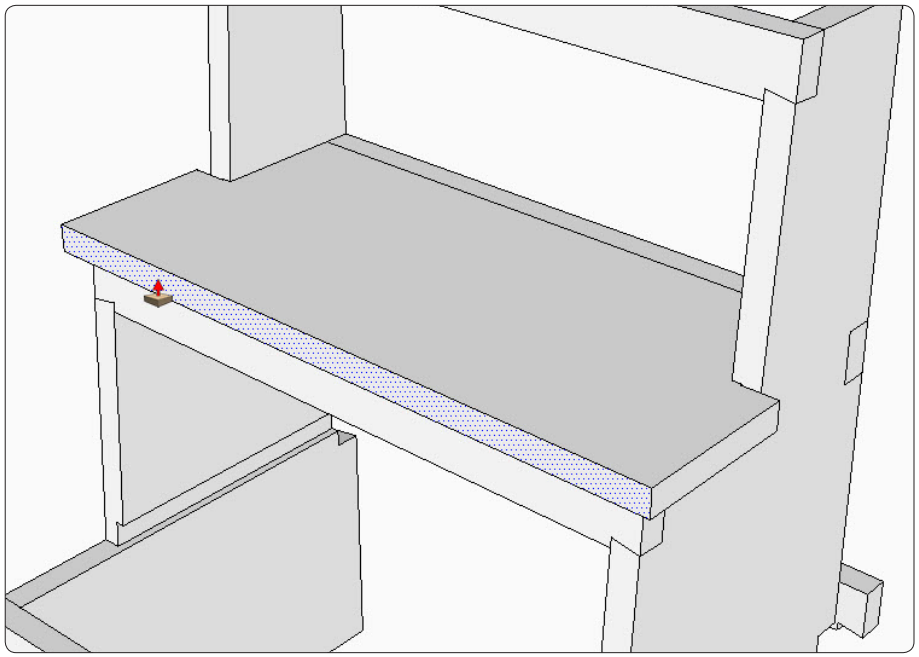


Figure 18. *Use the Push/Pull Tool to create overhangs on the sides and front of the step.*

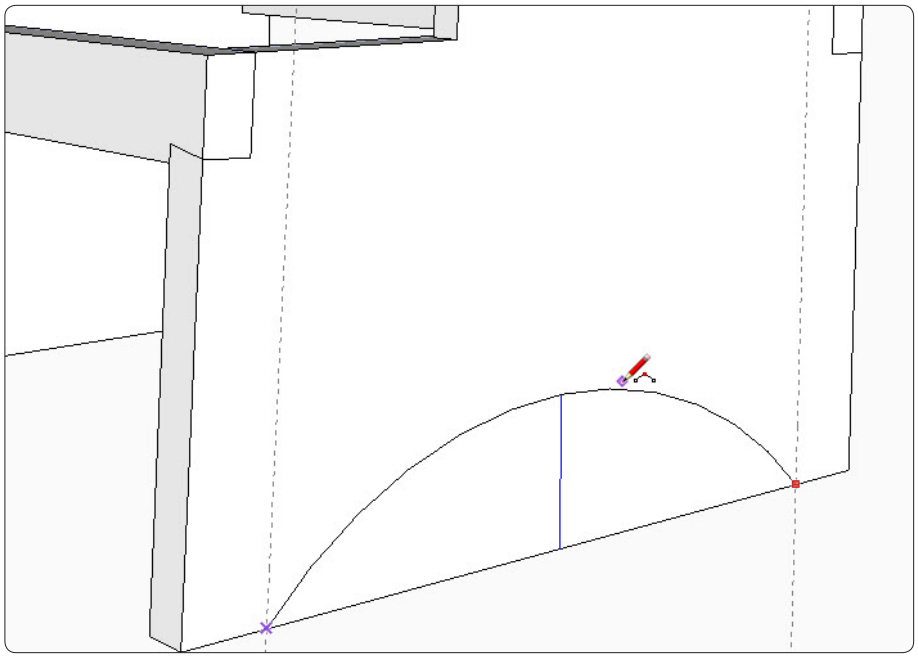


Figure 19. *Make the arc cutout in the side.*

out for a ½-in. overhang in front and on each side (Figure 18).

Step 15 Repeat Steps 13 and 14 to create the bottom step, giving it the same overhang on the front and sides. For the top step, draw the face over the perimeter of the piece, give it the proper thickness, then use the Push/Pull Tool to give it a ½-in. overhang on all four sides.

Step 16 Place two guide lines 1⅜ in. in from each edge of the side. Select the Arc Tool, and use it to click on the intersection of the guide lines and the bottom edge of the side. Move the mouse up along the blue axis, and type 3 3/4, which is the bulge for the arc (Figure 19). Press the Enter key to fix the arc. Use the Push/Pull Tool to push out the arc cutout.

Step 17 Round over the top edge of each step. The size of the roundover isn't critical, but I used a ¼-in. radius. Use the Arc Tool to draw the roundover shape on the back face of the step, on the side overhang, as shown in Figure 20. Select the top side and front edges of the step, then use the Follow Me Tool to click on the roundover shape (Figure 21). You can use the Soften/Smooth Edges function to remove extra lines on the roundover.

This completes the modeling of the step stool.

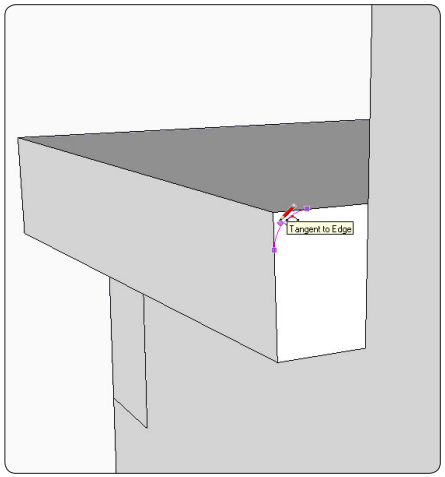


Figure 20. *Draw an arc on the back of the step, which will become a round-over on the top edge.*

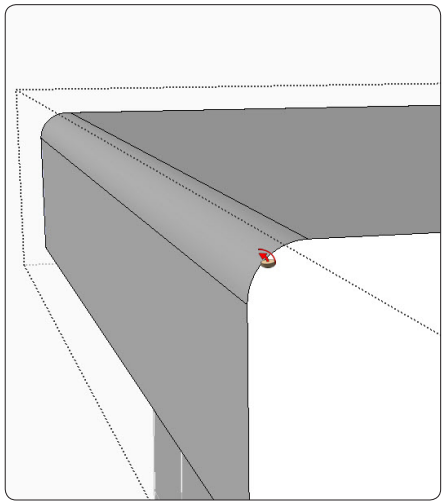


Figure 21. *Use the the Follow Me Tool to round-over the top edge of the step.*

The Windsor Chair

SketchUp sparked my recent interest in Windsor chairs. It wasn't until 2008 that I decided to reproduce a Windsor in SketchUp. It was a personal challenge: Could I develop enough of an understanding of Windsor construction so I could build one in the shop? I did, and I haven't stopped. By now, I've designed and constructed more than 20 Windsor chairs of all styles: bow backs, braced bow backs, sack backs, fan backs, comb backs, continuous bow, stools, and a settee. This became such an absorbing interest that I began teaching Windsor chair construction. As a result, I've worked with many others who have successfully built a number of Windsors—all as a result of SketchUp.

Developing the model revealed all the mysteries of Windsor construction. There are no right angles in the chair, so where do you start? What angle do you drill the seat sockets for the legs? What is the splay of the legs? How do you know what angle to drill the sockets for the steam-bent bow? How do you place sight lines on the seat? How do you drill the leg for the stretcher tenons? Those were a few of the unknowns at the start of the project. SketchUp modeling confidently provided the answers.

As one of my first projects, I selected a braced bow-back Windsor chair from *Furniture Treasury,* by Wallace Nutting. In the book, Nutting provided three orthographic, dimensioned views of the chair, which I scanned into SketchUp. If you have the book, you can work with the same scanned images. Otherwise, use Figures 23 and 24. They are equivalent to the drawings provided in the book. You can scan those drawings into SketchUp and reconstruct the model following the steps given below. Figure 22 shows a nearly completed model. Chapter 11 explains how to handle imported images.

Step 1 Scan and scale the top view of the seat from Figure 23 and import it into SketchUp. Use the Line and Arc Tools to trace over the shape. Because the seat is symmetrical, you need to trace only the half that's shown in the drawing.

Seat illustrations often show lines representing the bottom face of the seat, so that you know how much to shape the edges of the seat. They are radiused substantially, as shown in Figure 25. I also capture these shapes in the trace-over. After giving the seat face a thickness, I move these setback shapes from the top face of the seat to the bottom face.

Step 2 Use the Circle Tool to make the seat sockets for spindles, legs, and the back bow. Mark the center of each socket with a guide point. This will come in handy for many of the steps to follow. To create a guide point, right-click on the circumference of the circle. Choose Point at Center from the pop-up menu. (If that doesn't work, click on Window in the Menu Bar and choose Preferences. On the Mac, click on SketchUp and Preferences. In the System Preferences dialog box, click on Extensions. Make sure that Ruby Script Examples is checked. Then try to place the guide point again.)

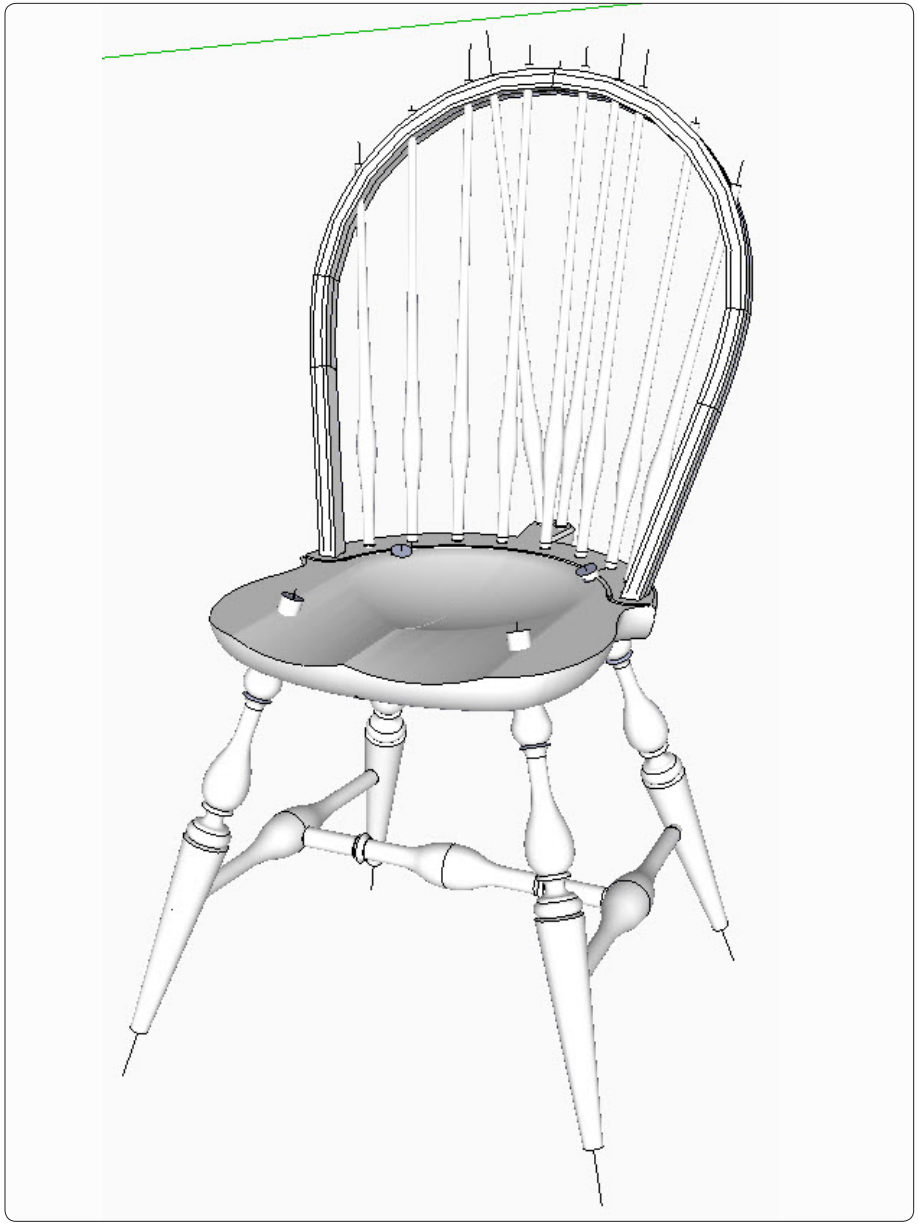


Figure 22. *The bow-back Windsor model, nearly complete. All that remains is to trim the ends of the spindles and legs.*

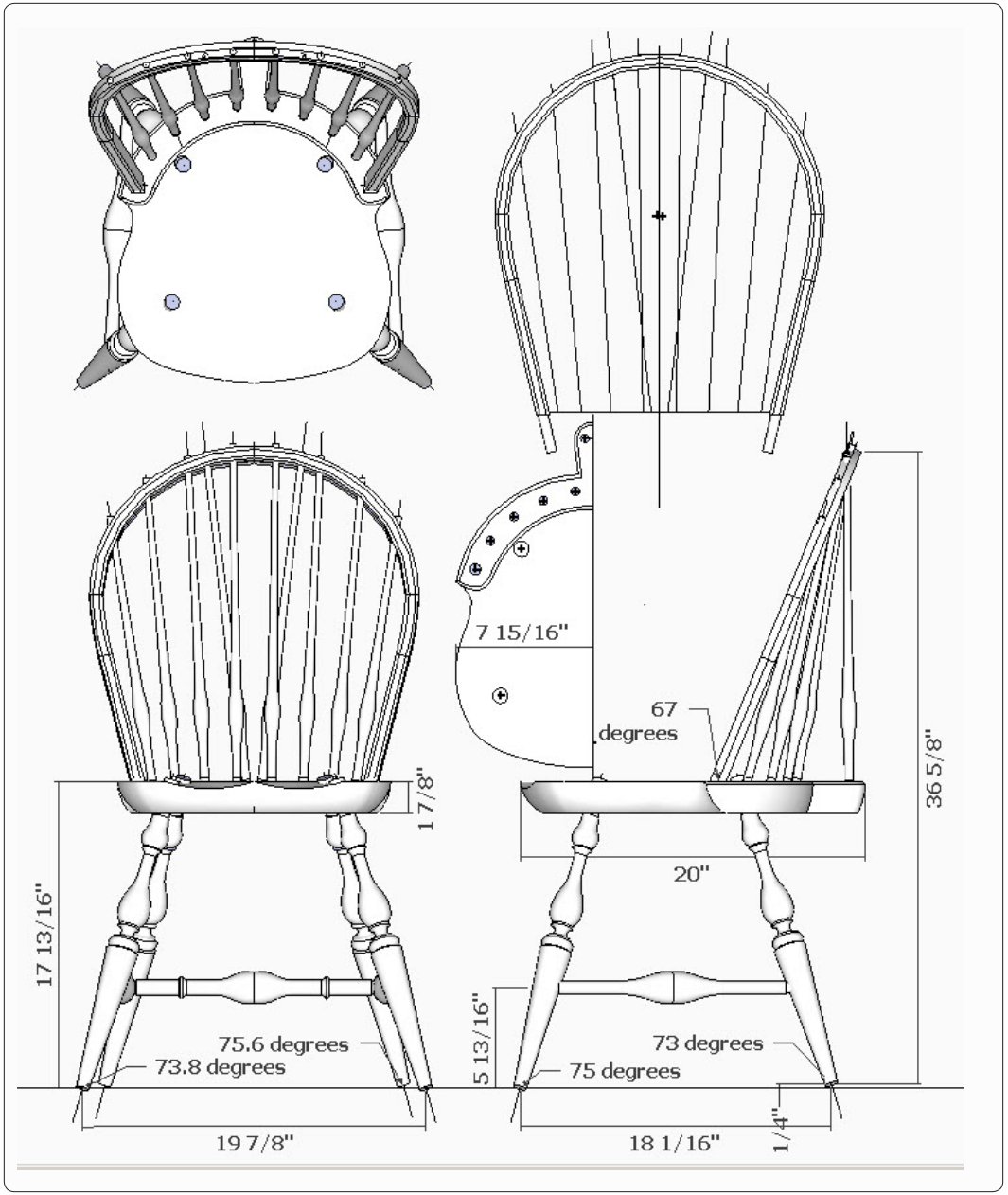


Figure 23. *Top, front, and side views of the bow-back Windsor chair.*

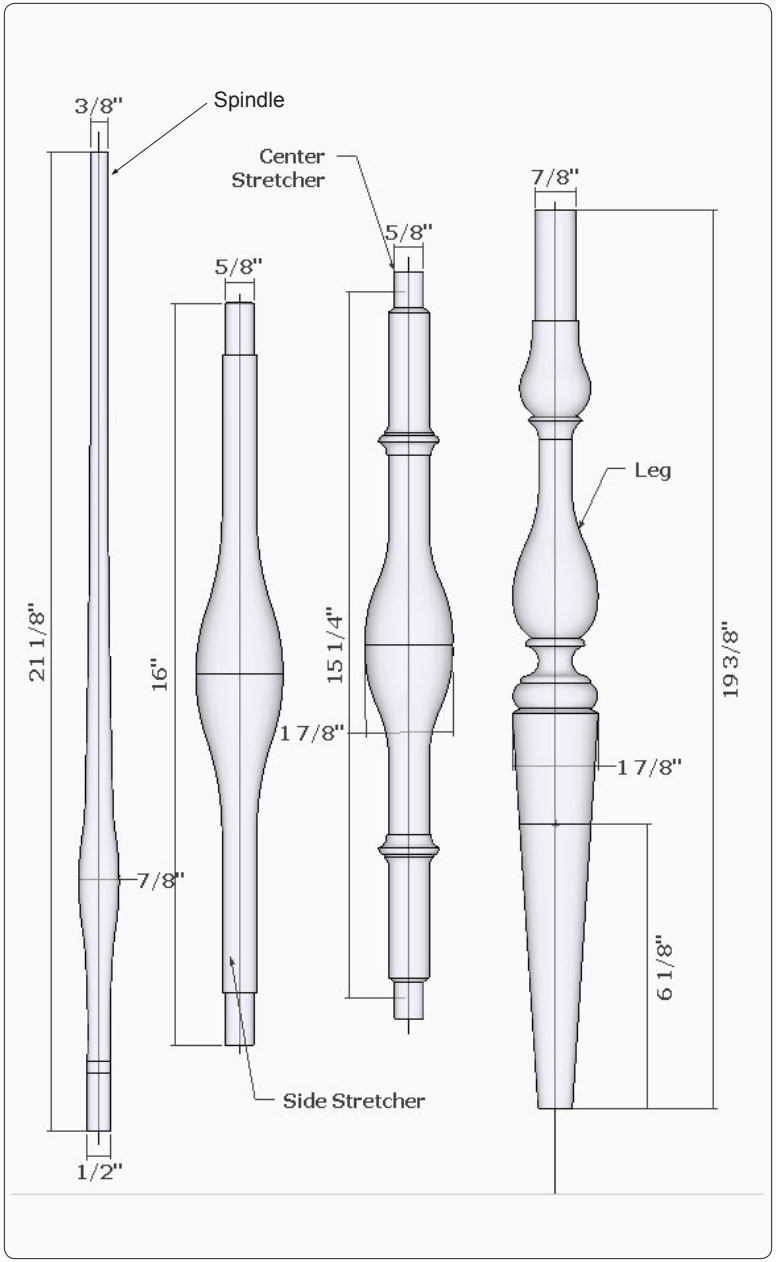


Figure 24. *Dimensioned drawings of the four Windsor turnings.*

Step 3 Use the Push/Pull Tool to give the shaped seat its thickness, usually between 1¾ in. and 2 in. In this example, the seat is 1⅞ in. thick. You should have a component that looks like the one in Figure 26.

Step 4 Scan and scale Figure 24, the turnings, and import it into SketchUp. Use the Line and Arc Tools to trace over the leg shape, resulting in a flat face as shown in Figure 27. Add a guide point and horizontal line 6⅛ in. from the bottom, as shown in the figure. This will produce a ring where the stretcher intersects the leg. The extra line means that the leg will have to be "turned" in two stages. Be sure to draw centerline extensions at both ends of the leg shape. They are essential for positioning the legs in the seat.

Step 5 Create the path for the Follow Me Tool, as shown in Figure 28. The size of the circle doesn't matter, but be sure its radius follows the red axis to line up with the leg shape face. Select the path, then select the Follow Me Tool, and click on the top portion of the leg shape. Repeat for the bottom portion. The result is shown in Figure 29. If you haven't already done so, make the leg a component.

The Follow Me Tool deletes the centerline within the turning, although the extensions at each end remain. Select the component for editing and use the Line Tool to re-create the centerline from extension endpoint to endpoint. This will help later in the process.

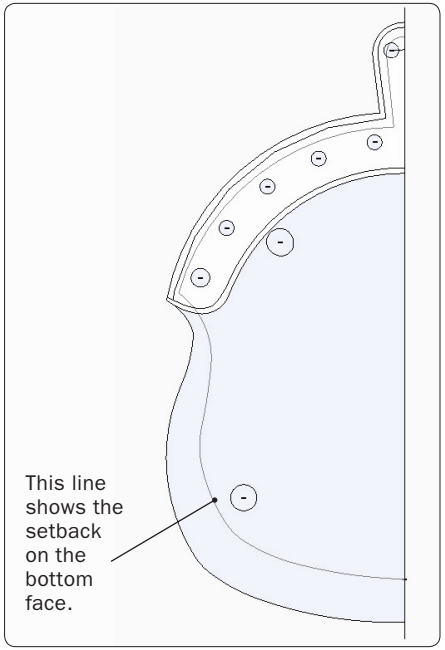


Figure 25. *Trace over the imported seat image.*

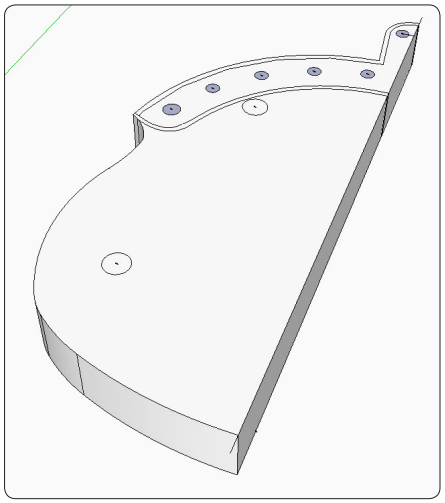


Figure 26. *The seat blank, given its thickness and with socket locations drawn in place.*

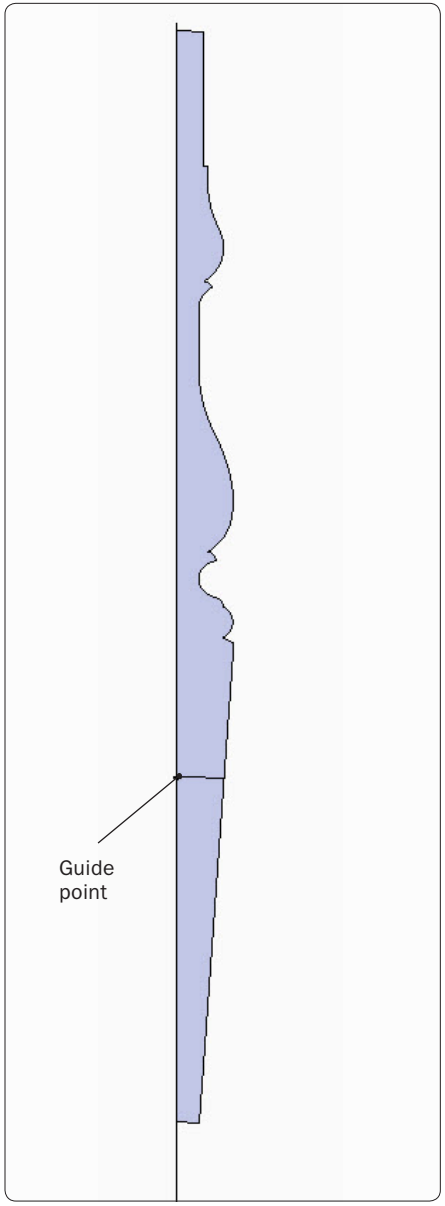


Figure 27. *Trace half the profile of the leg, and add a guide point and line to help position the stretcher properly.*

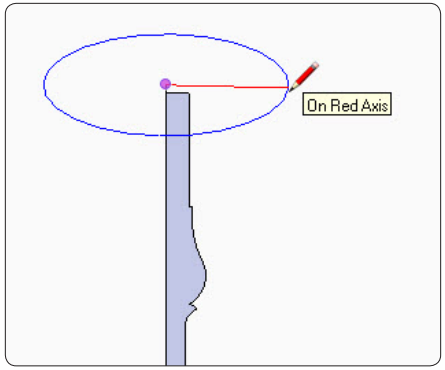


Figure 28. *Draw a circle to make a path for the Follow Me Tool. Be sure the circle's radius is on the red axis, so it lines up with the leg shape.*

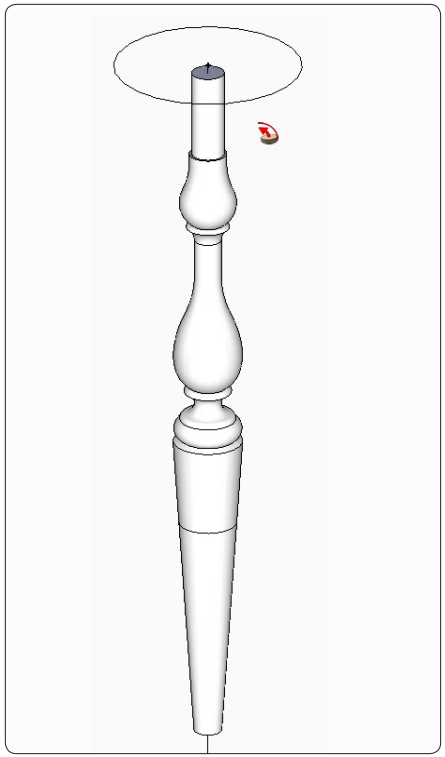


Figure 29. *The completed leg.*

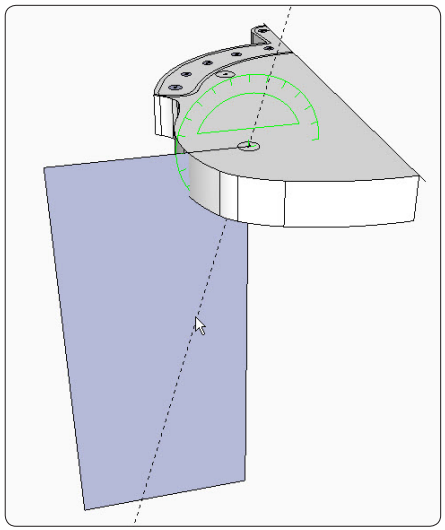


Figure 30. *The guideline on the rectangle parallels the one angle of the front leg.*

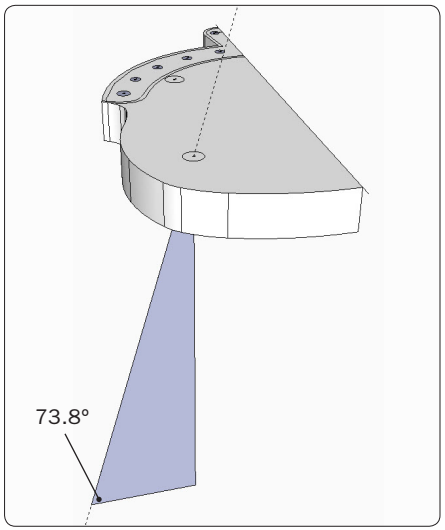


Figure 31. *Draw over the guideline, then erase waste to leave the triangle shown.*

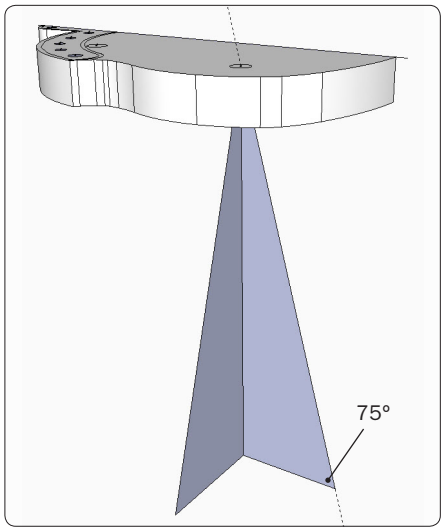


Figure 32. *Create a second triangle, which defines the angle of the leg from the side.*

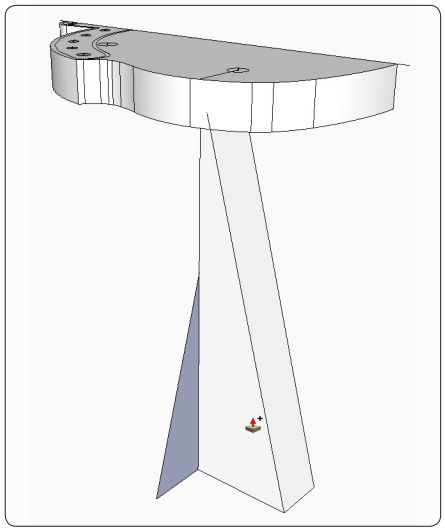


Figure 33. *Use the Push/Pull Tool to give each triangle thickness. The resulting shapes should fully intersect each other.*

Step 6 Now, you'll create a centerline model to find the angle and orientation of the front and back legs. Make a centerline diagram, using the leg angles for the front and side, as given in Figure 24. You could use geometry to calculate this compound angle, but I find it easier to do it by intersecting shapes in SketchUp.

Draw a rectangle on the red–blue axis that has one corner at the center of the front leg socket on the top surface of the seat. The length of the rectangle on the blue axis should be 17$^{13}/_{16}$ in. The width isn't critical, but should be about 8 in.

Select the Protractor Tool and hover over the face of the rectangle; the cursor should be green. Press and hold the Shift key as you move the protractor to the center of the leg socket. Use the Zoom Tool to move in close and click the mouse when the cursor meets the guide point at the circle's center. Move the mouse along the red axis, and click on the top left corner of the rectangle. Then move the mouse to create an angled guide line; next, type 73.8, the angle of the leg in the front view. Figure 30 shows the resulting guide line. Trace over the guide line and erase the top left corner of the rectangle, leaving the triangle shown in Figure 31. Repeat these steps to create a second angled triangle for the angle of the leg from the side (Figure 32).

Step 7 Select the Push/Pull Tool and pull out each triangle; they should fully intersect each other. Tap the Ctrl key (Option on the Mac) to make the Push/Pull Tool pull out one face over the top of the other triangle. Figure 33 shows one triangle pulled out part way. When you've completed the two shapes, draw a line over the seam of the intersection, starting at the center point of the seat socket (Figure 34). This creates an angled centerline for the front leg.

Step 8 Repeat Steps 6 and 7 to create an angled centerline for the rear leg. Select both centerlines and make them a component called Centerline, as shown in Figure 35.

Step 9 Bring the leg components into view and copy them. Use the Move/Copy Tool to connect the bottom center point of each leg to the end of its respective centerline. Set the Face View to X-Ray View and use the Zoom Tool to come in close to be sure that the leg center point is actually connected to the endpoint of the centerline (Figure 36).

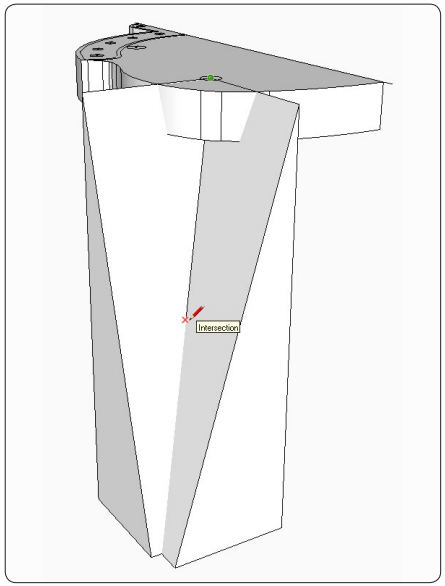


Figure 34. *Draw a line along the seam where the two triangular shapes intersect.*

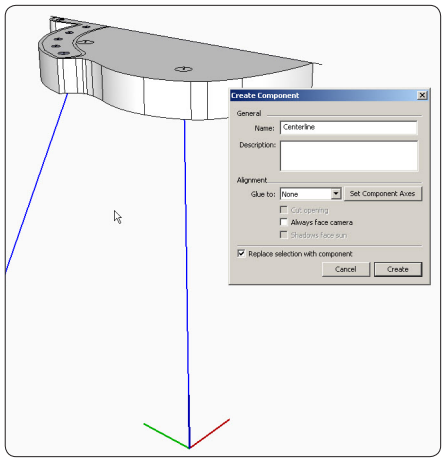


Figure 35. *Make the centerlines for the legs a component.*

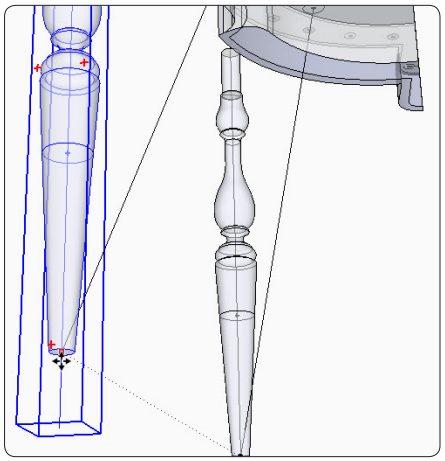


Figure 36. *Connect the bottom center of the legs to the centerlines.*

Step 10 Now, you'll create a rotation plane that will allow you to rotate the legs so they align with the centerlines. Use the Tape Measure Tool to double-click on the centerline component and on the leg centerlines. This creates two intersecting guide lines. Draw a four-sided shape between the guide lines, as shown in Figure 37. The size of the shape doesn't matter, because it will be used only temporarily to set the Rotate Tool.

Use the Select Tool to click on the front leg, then select the Rotate Tool. Hover the tool over the small four-sided shape; the cursor will turn black. Press the Shift key and hold it down until you have successfully clicked the Rotate Tool on the bottom center point of the leg. You will need to use the Zoom Tool to get in close enough to make this connection.

Click the mouse on the guide line that coincides with the leg centerline. That will start the leg rotation. Move the mouse over to the other guide line. Click the mouse to end the leg rotation (Figure 38). The leg is now oriented properly for its seat connection. Orbit up to the top of the seat to be sure that the leg protrudes through the seat socket. Repeat these steps to rotate the rear leg.

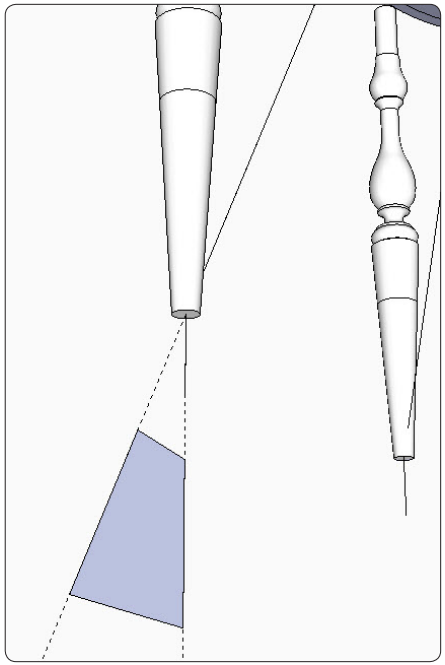


Figure 37. *Set a pair of guide lines, one aligned with the leg and the other with the centerline. Use them to draw a four-sided face.*

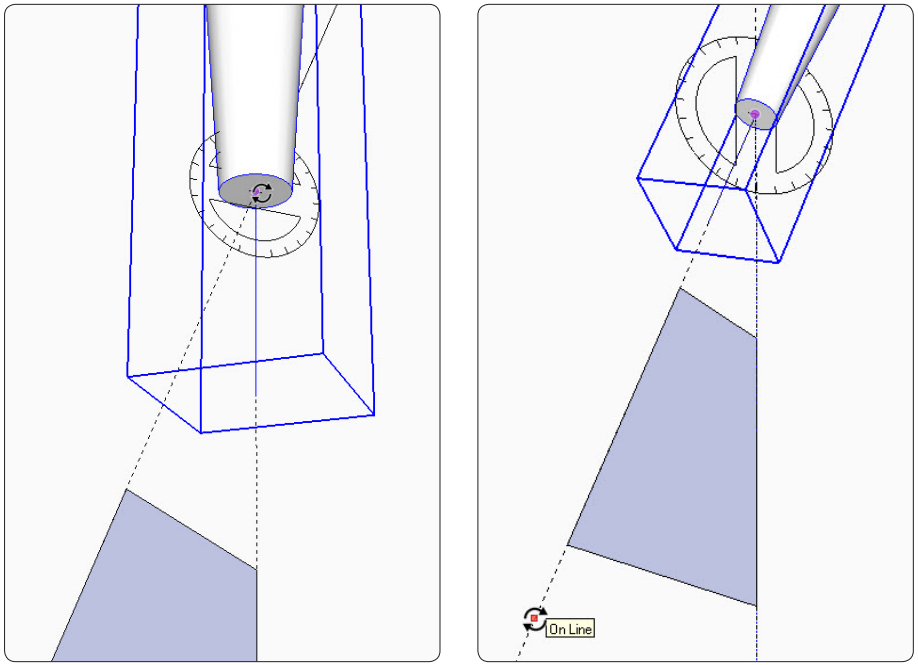


Figure 38. *To begin rotating the leg, Connect the Rotate Tool with the bottom centerpoint of the leg, then click on the guide line coinciding with the leg centerline (left). Move the mouse over to the other guide line (right), and click again to end the rotation.*

Step 11 Set the Face View to X-Ray. Draw a line between the two guide points in the legs, as shown in Figure 39. This line needs to become a part of the Centerline component created in Step 8. Right-click on the front leg and select Hide from the pop-up menu. This lets you access the Centerline component. Right-click on the centerline for the front leg and select Edit Component from the pop-up menu. Use the Line Tool to draw over the existing line between the two guide points. Unhide the leg.

Step 12 Make a side stretcher, just as you did the legs, and copy it over to your model. When you make the turning, be sure to include the horizontal centerline, as shown in Figure 24. Use the Move/Copy Tool to connect the center point on the end of the stretcher to the guide point in the front leg. Set the Face View to X-Ray to see the guide point inside the front leg, as shown in Figure 40.

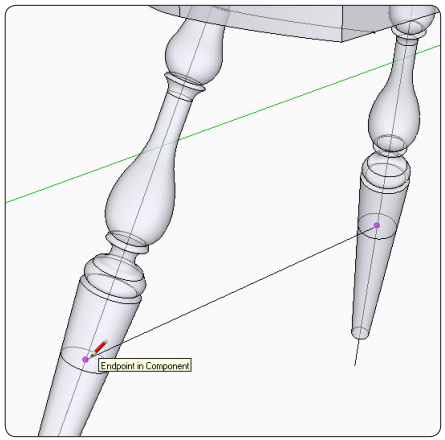


Figure 39. *Draw a line between the guide points in the legs. Then select the Centerline component, and draw over this line to make it part of the component.*

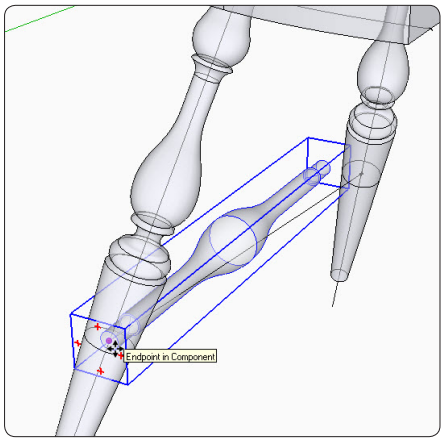


Figure 40. *Connect the stretcher to the front leg, using the guide points and centerpoints created when you made the turnings.*

Step 13 Rotate the side stretcher into position the same way you rotated the legs: Create one guide line over the centerline of the stretcher and another on the Centerline component, then draw a small four-sided flat face to set the Rotate Tool. Select the side stretcher, then select the Rotate Tool. Hover over the flat face while you hold the Shift key. Connect the Rotate Tool to the guide point in the leg. Complete the rotation by clicking on one guide line then the other (Figure 41).

Step 14 Select all the components of the half chair. Use the Move/Copy Tool to make a copy and move it to the right, along the red axis. Use the Flip Along function. Join the two halves, using the top front corner as the connection point, as shown in Figure 42.

Step 15 Set the Face View to X-Ray and draw a line between the centers of the two side stretchers, as shown in Figure 43. Make this a part of the Centerline component as you did before. Bring a copy of the Center Stretcher component into the model. Use the Move/Copy Tool to connect the end of the stretcher to the midpoint of the side stretcher, as shown in Figure 44.

Step 16 Hide the undercarriage copy as well as the legs and stretchers, leaving only half the seat and the Centerline component, as shown in Figure 45. You'll use this component to help determine the angle of the drilled sockets in the legs and in the side stretchers. I use this type of diagram in the documentation package used in the shop. Place small arc shapes on the applicable planes, then use the Protractor Tool to measure the angles.

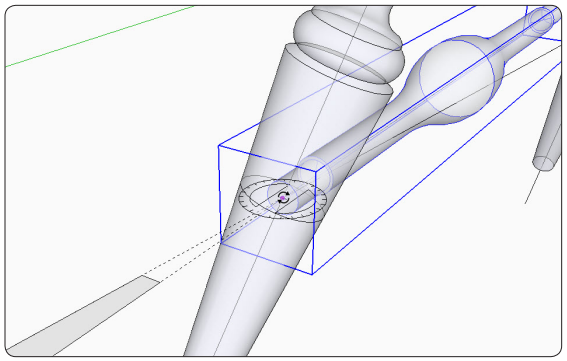


Figure 41. *Draw two guidelines and a small flat face between them to set the rotation of the stretcher.*

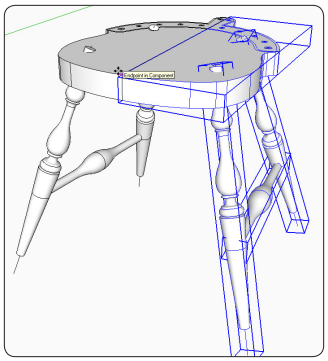


Figure 42. *Copy the half chair and join it to the original.*

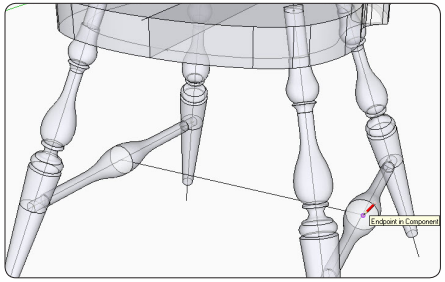


Figure 43. *Connect the centers of the side stretchers, then make the line part of the Centerline component.*

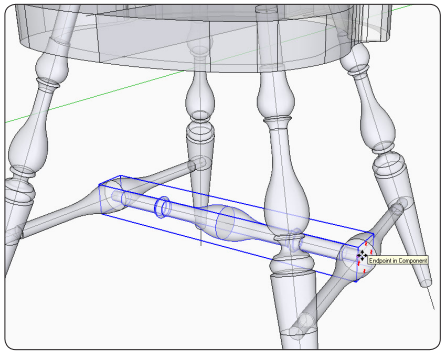


Figure 44. *Add the center stretcher, connecting it to the centers of the side stretchers.*

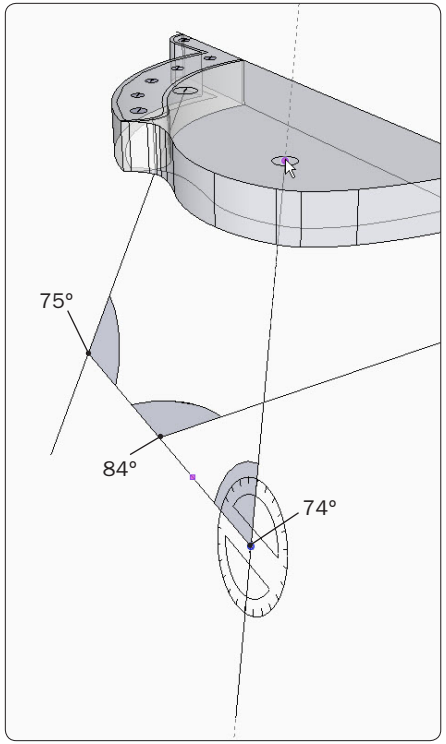


Figure 45. *Add information to the Centerline component, which will help drill holes for the legs at the proper angles.*

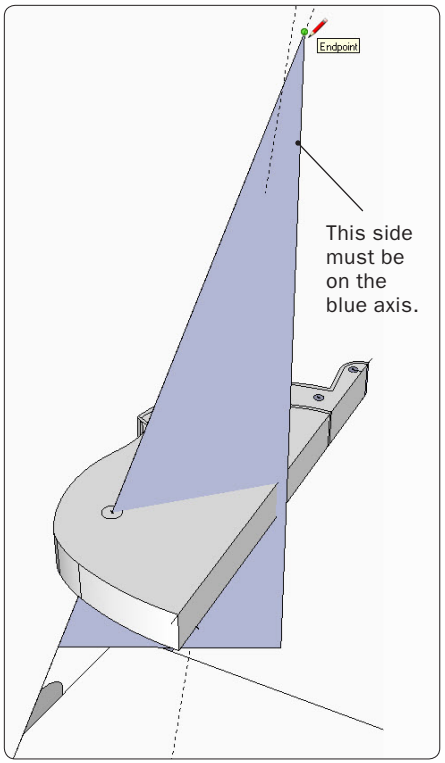


Figure 46. *To place sight lines for drilling the leg sockets, begin by drawing a triangle that intersects the seat.*

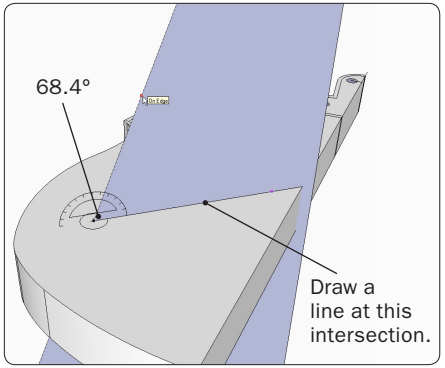


Figure 47. *Draw a line where the triangle intersects the seat, then measure the angle.*

Step 17 Use the Centerline component to determine the drilling angle and sight line for the leg sockets in the seat. (Sight lines, commonly used in Windsor chair making, are transferred to the actual seat blank and help the woodworker drill properly angled sockets.) Use the Tape Measure Tool to double-click on the leg centerlines. This creates guide lines on which to draw a tall triangle that intersects with the seat. Its actual size is unimportant, so long as it extends past the centerline of the seat, as shown in Figure 46. Draw over the guide line first, then extend the line down the blue axis, and finish by connecting with the line over the guide line.

Step 18 Select the seat component for editing, then use the Line Tool to draw a line where the triangle intersects the seat face. Use the Tape Measure to check the angle formed by the line across the seat face and hypotenuse of the triangle (Figure 47). Delete the triangle. Repeat these steps for the rear leg.

The undercarriage of the chair is now complete, as Figure 48 shows. Later, you will add more sight lines for the bow and spindle sockets.

Step 19 From Figure 23, scan the view of the back bow and import it into your SketchUp file. Trace over the scanned image, and scale it so that the front face of the bow is ¾ in. wide (Figure 49). After tracing over the shapes, use the Push/Pull Tool in two steps to give the bow thickness and keep the spindle centerlines centered. Pull the front face of the bow out 7⁄16 in. Use the Orbit Tool to move to the back side of the bow, and pull that face out 7⁄16 in. (Figure 50).

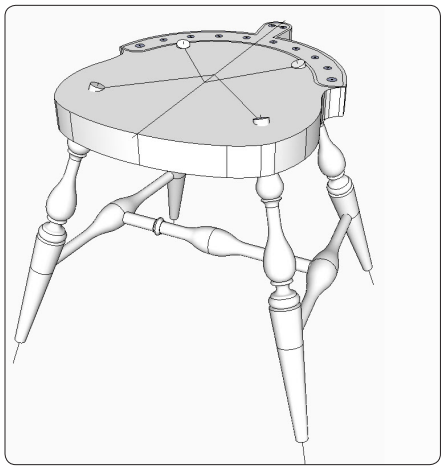


Figure 48. *Now, all the chair needs is the bow back and spindles.*

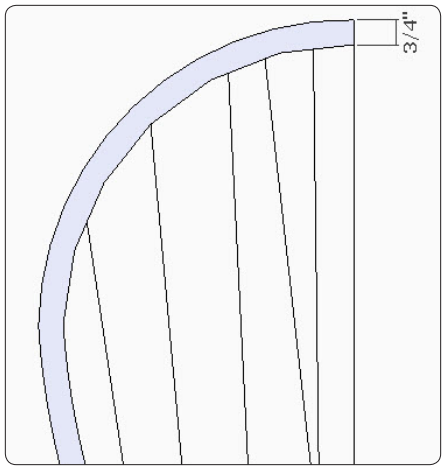


Figure 49. *Trace over the bow shape and the centerlines for the spindles.*

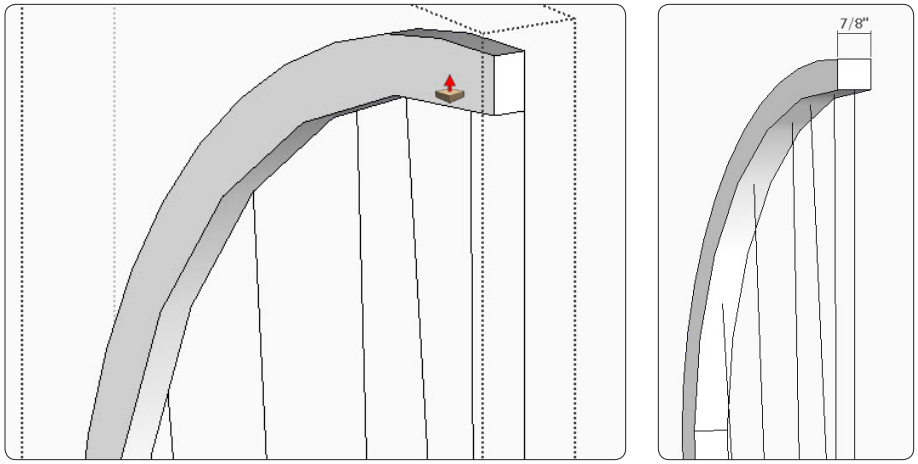


Figure 50. *Give the bow its thickness from the front, then from the back, to keep the spindle centerlines centered on the bow.*

Step 20 Use the Push/Pull Tool to make the square tenon at ⅝ in. on a side. Draw a circle on the end face of the tenon. Use the Follow Me Tool to push away the waste, creating the cylindrical tenon (Figure 51).

Step 21 Use the Move/Copy Tool to rotate the bow to its 67-degree angle.

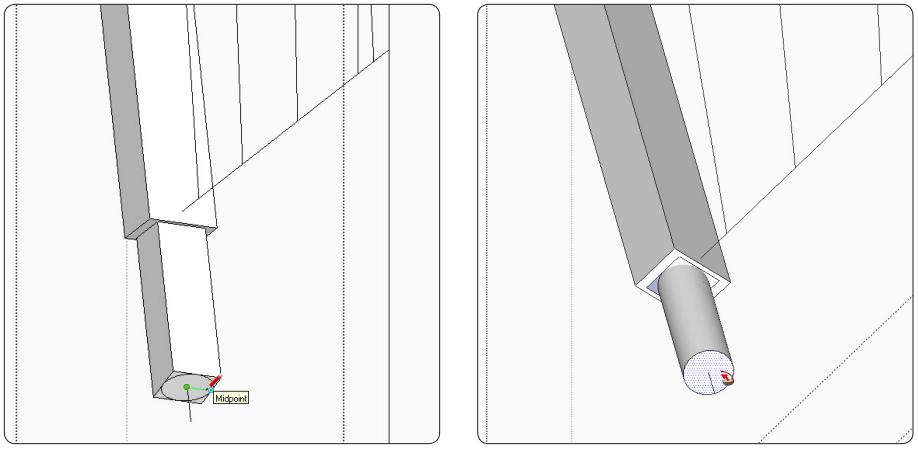


Figure 51. *First, use the Push/Pull Tool to make the tenon ⅝ in. square. Draw a circle on the end, then use the Follow Me Tool to remove the waste, leaving the cylindrical tenon shown at right.*

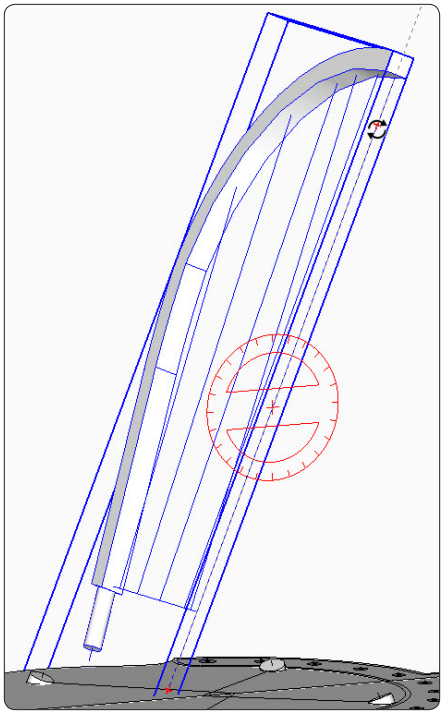


Figure 52. *Rotate the bow to 67 degrees.*

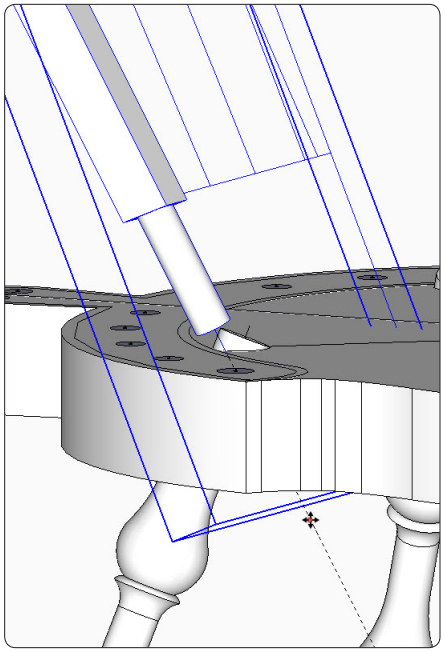


Figure 53. *Place a guide line along the bow centerline, and use it to guide the bow into the seat.*

Hover the tool over the bow component and look for the red plus signs. Click on one of the plus signs and begin the rotation. Type 67 and press the Enter key (Figure 52).

Use the Move/Copy Tool to connect the endpoint of the bow centerline to the guide point in the center of the seat socket. Select the Tape Measure Tool and double-click on the bow centerline to create a guideline to help align the bow.

Select the Move/Copy Tool and click on the guideline (I find it easier to do this from the underside of the seat). Use the Orbit Tool to go back to the top of the seat. Because the bow is still selected, the Move/Copy Tool will move the bow into the socket. Carefully move the mouse icon down the guide line and watch the bow slide into its socket (Figure 53). Stop the move when the front edge of the bow touches the top face of the seat.

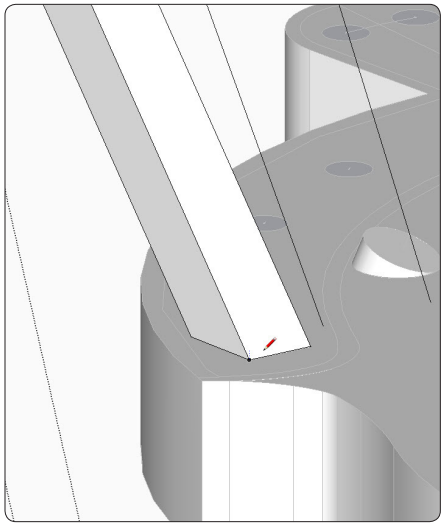


Figure 54. *Draw lines where the bow intersects the seat, so you can trim the shoulder of the tenon at the proper angle.*

Step 22 The end of the square section of the bow at the base of the tenon is not trimmed to be flush with the seat. To fix that, open the bow for editing, then select the Line Tool. Draw lines around the bow where it intersects with the top face of the seat, as shown in Figure 54. Make a copy of the bow and move it away from the assembly. Clear out the waste wedge shape. Now the bow will sit flush to the seat (Figure 55).

Step 23 To mark spindle hole locations on the upper surface of the bow, use the Line Tool to extend the spindle centerlines, as shown in Figure 56.

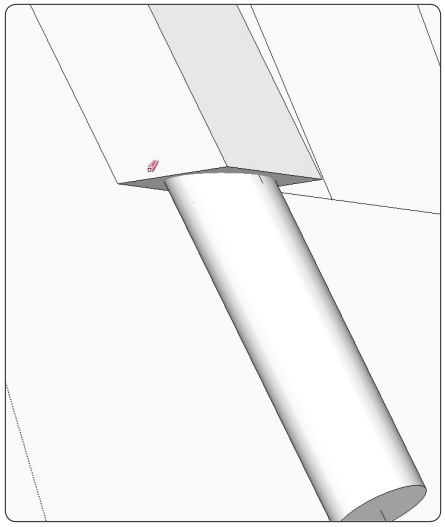


Figure 55. *The angled shoulder, after the waste has been removed at the base of the tenon.*

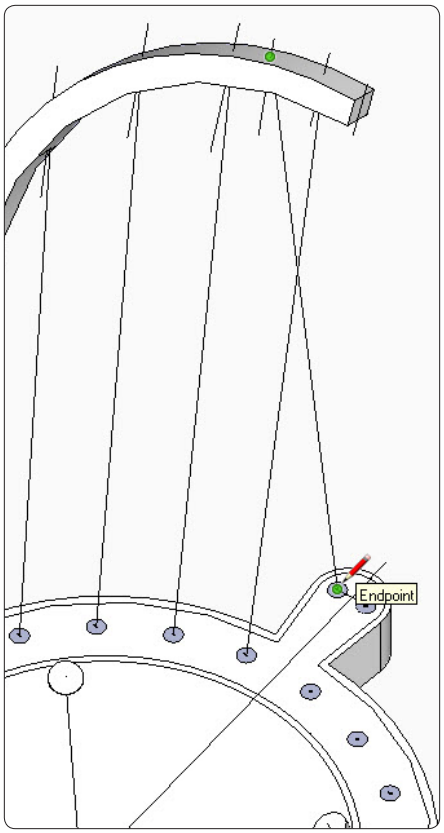


Figure 57. *Draw centerlines connecting the guide points on the spindle sockets with the spindle hole centers on the top of the bow.*

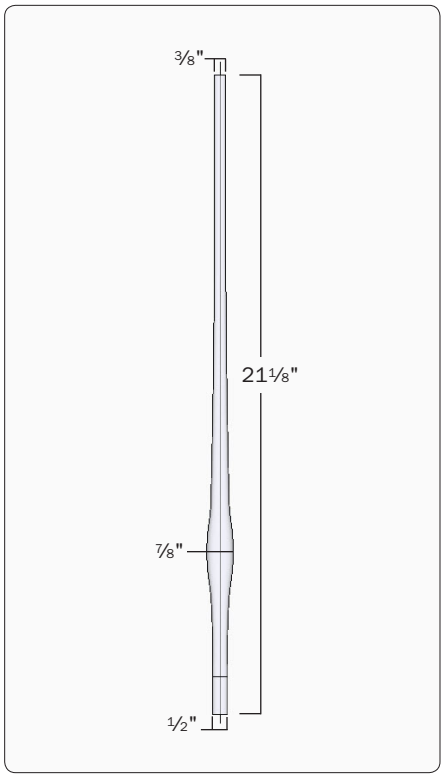


Figure 58. *The longest spindle. When you draw the face for this turning, be sure to add the line near the bottom, which will create a ring to help determine how far to drive the spindle into its socket.*

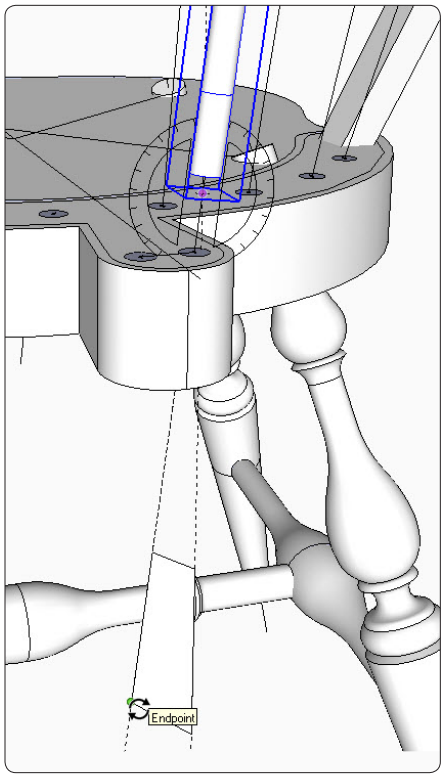


Figure 59. *Rotate each spindle to line up with its centerline, following the same procedures you used to align the legs and side stretchers.*

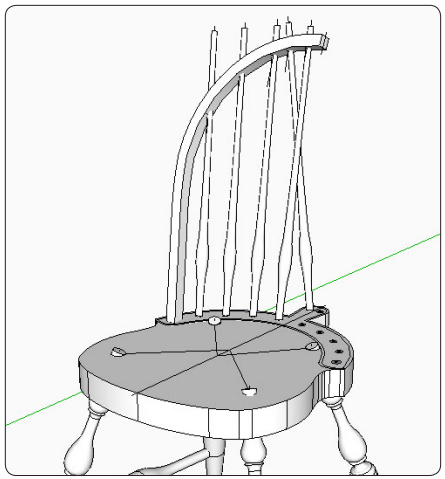


Figure 60. *All the spindles have been rotated into place.*

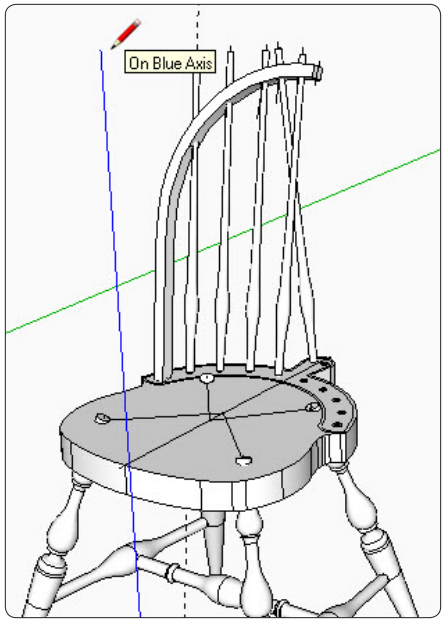


Figure 61. *To create sight lines for the spindle sockets, first place a guide line, then draw a vertical line that begins at the guide line and passes in front of the seat.*

Then draw spindle centerlines from the center of the seat sockets to the spindle hole centers on the top of the bow, as shown in Figure 57.

Step 24 Using Figure 24, create a spindle component, just as you created the legs and stretchers. Figure 58 shows the longest spindle. If you wish, you can make shorter versions to better fit positions at the side of the bow. Push the top down with the Move/Copy Tool.

Copy the spindle and connect its endpoint to the centerline near the top face of the seat. Follow the procedure in Step 10—drawing two guide lines, with a small four-sided face between them, then using the Rotate Tool—to rotate the spindle so it lines up with the centerline (Figure 59). Use the Move/Copy Tool to drive the spindle into its seat socket (to the marked ring). Repeat this step for all of the spindles. Figure 60 shows all the spindles in their final position.

Step 25 In this step, you'll create sight lines on the seat face that will be used in the shop to drill the spindle sockets. You'll also measure the drilling angle for each socket.

Select the Tape Measure Tool and double-click on a spindle centerline

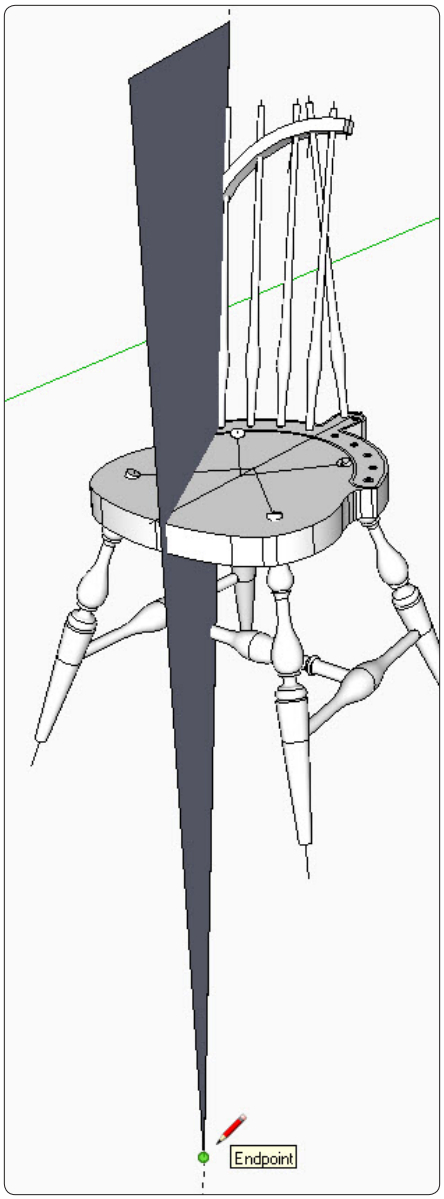


Figure 62. *Draw a line where the triangle intersects the seat to create the sight line. Do this for each spindle.*

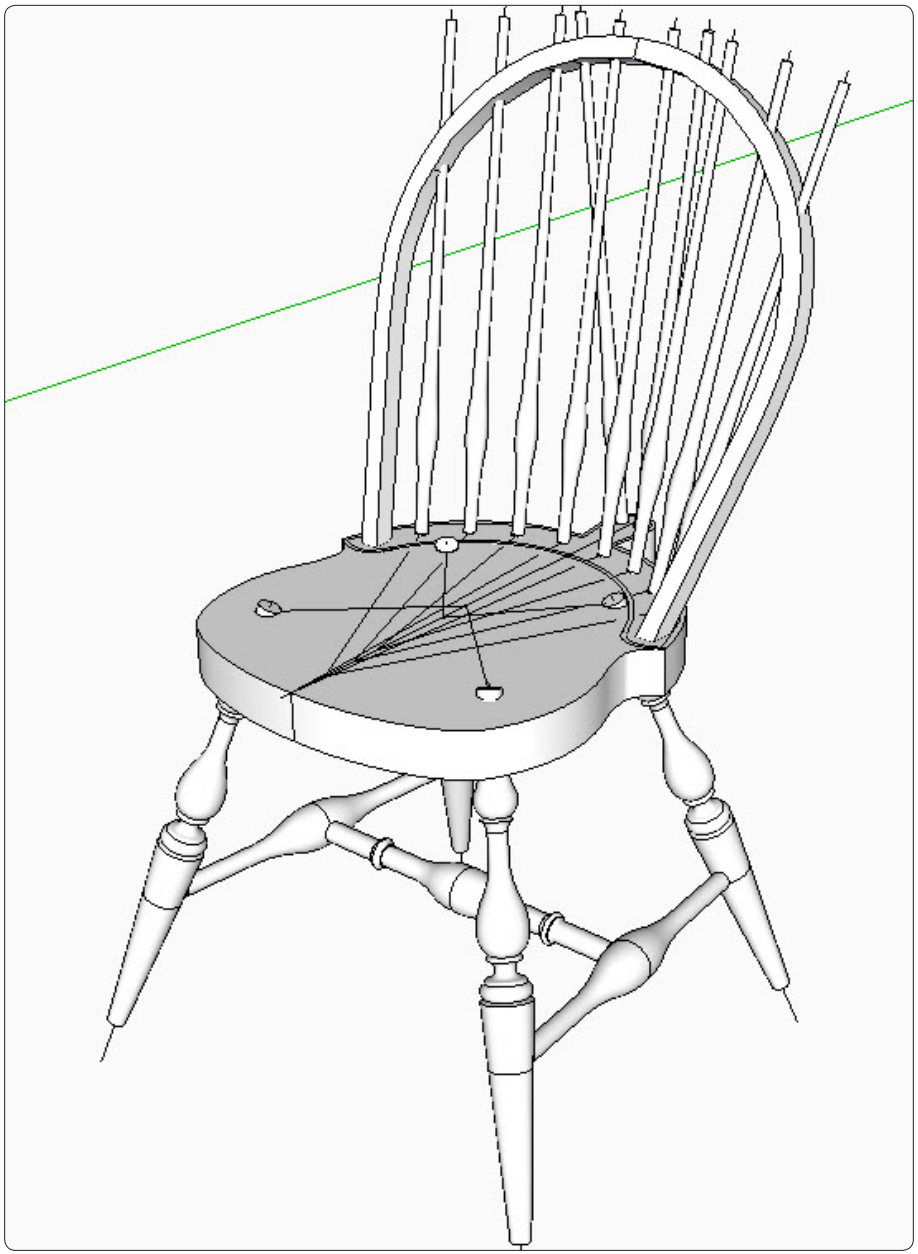


Figure 63. *The completed bow-back Windsor chair.*

to create a guide line. Then draw a line from the guide line along the blue axis. Draw the line so that it passing in front of the seat, as shown in Figure 61.

Continue with the Line Tool, as shown in Figure 62, and trace over the guide line. This creates a triangular plane that cuts through the seat. Where the plane intersects the seat face, draw a line for the sight line. Use the Protractor Tool to measure the angle of the spindle socket (I find it easier to use the bottom face of the seat). Make a note of the angles; like the sight lines, they are useful in the shop. Delete the triangular plane and guideline, and move to the next spindle. Repeat for each spindle.

Step 26 Select the bow and all the spindles. Use the Move/Copy Tool to make a copy, then execute a Flip Along command. Join the copy to the original at the top front corner of the bow.

Congratulations! You've successfully completed a difficult and tedious Windsor chair design. The tools and techniques you used here will be very helpful in all kinds of furniture projects. Figure 63 shows the final design with all the sight lines drawn on the seat. There are a few embellishments that I'll leave for you to finish. For example, I haven't trimmed the spindles, sculpted the seat, or placed a molding on the front face of the bow. I'll cover some techniques for sculpting and molding in the next chapter.

Colonial Cupboard

So far I've shown step-by-step instructions for designing a broad array of furniture types, covering a broad spectrum of design characteristics. This section covers one more important type of furniture: case goods. The example is the small colonial cupboard shown in Figure 64. It's based on one described in an article by Mike Dunbar in *Fine Woodworking* #151. While copying the basic design and overall dimensions, I've made a few minor changes in number and spacing of shelves, carcase dovetails, and molding shapes.

I won't go through every step in making this piece. Instead, I'll focus on procedures for unique construction features.

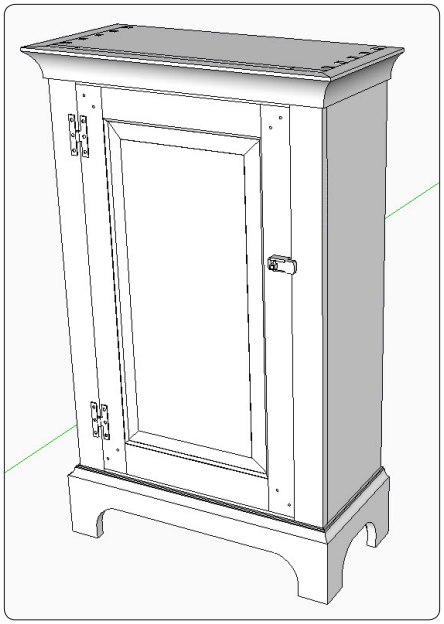


Figure 64. *A colonial cupboard makes for a good exercise in designing case goods.*

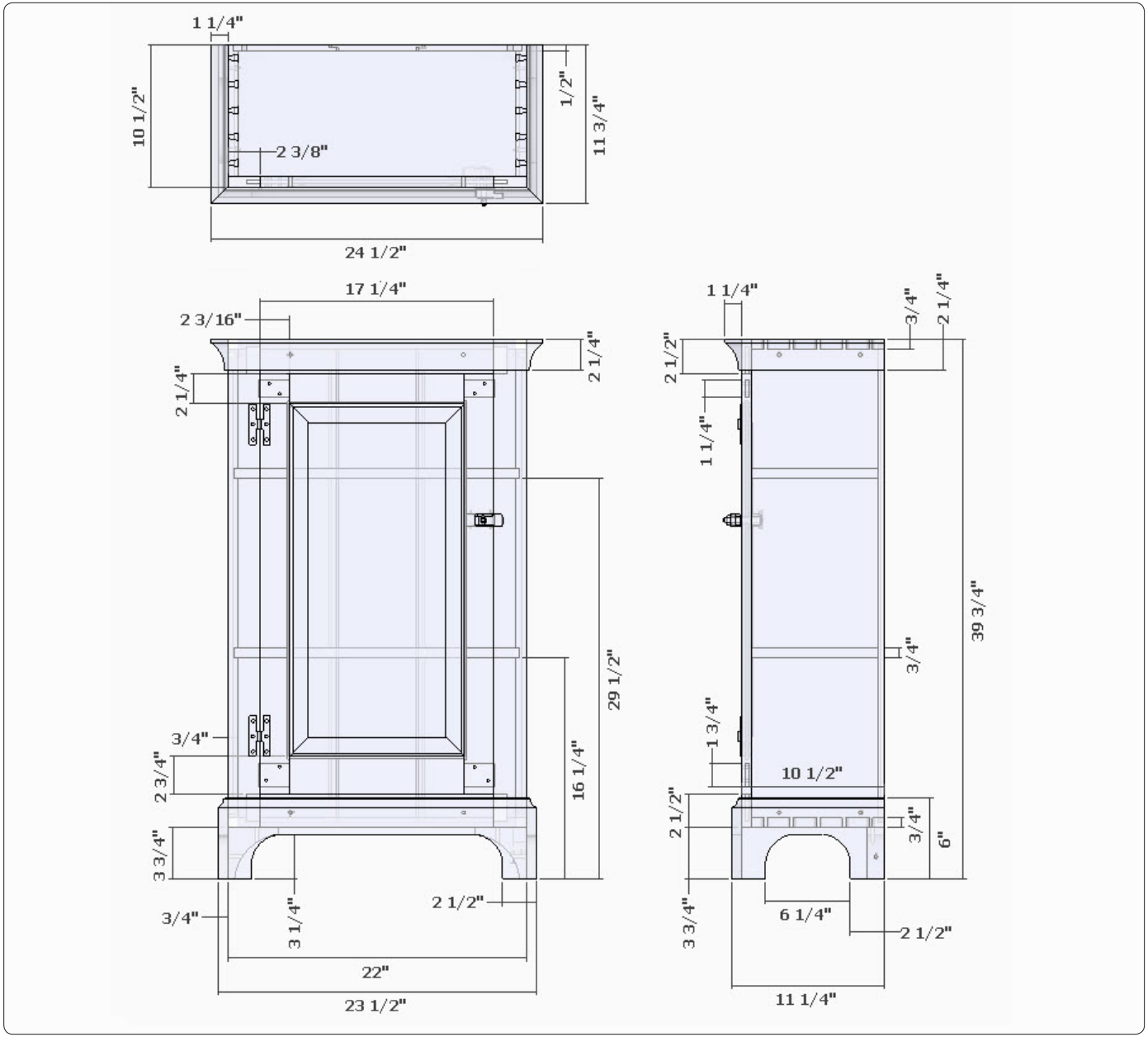


Figure 65. *Measured top, front, and side views of the cupboard.*

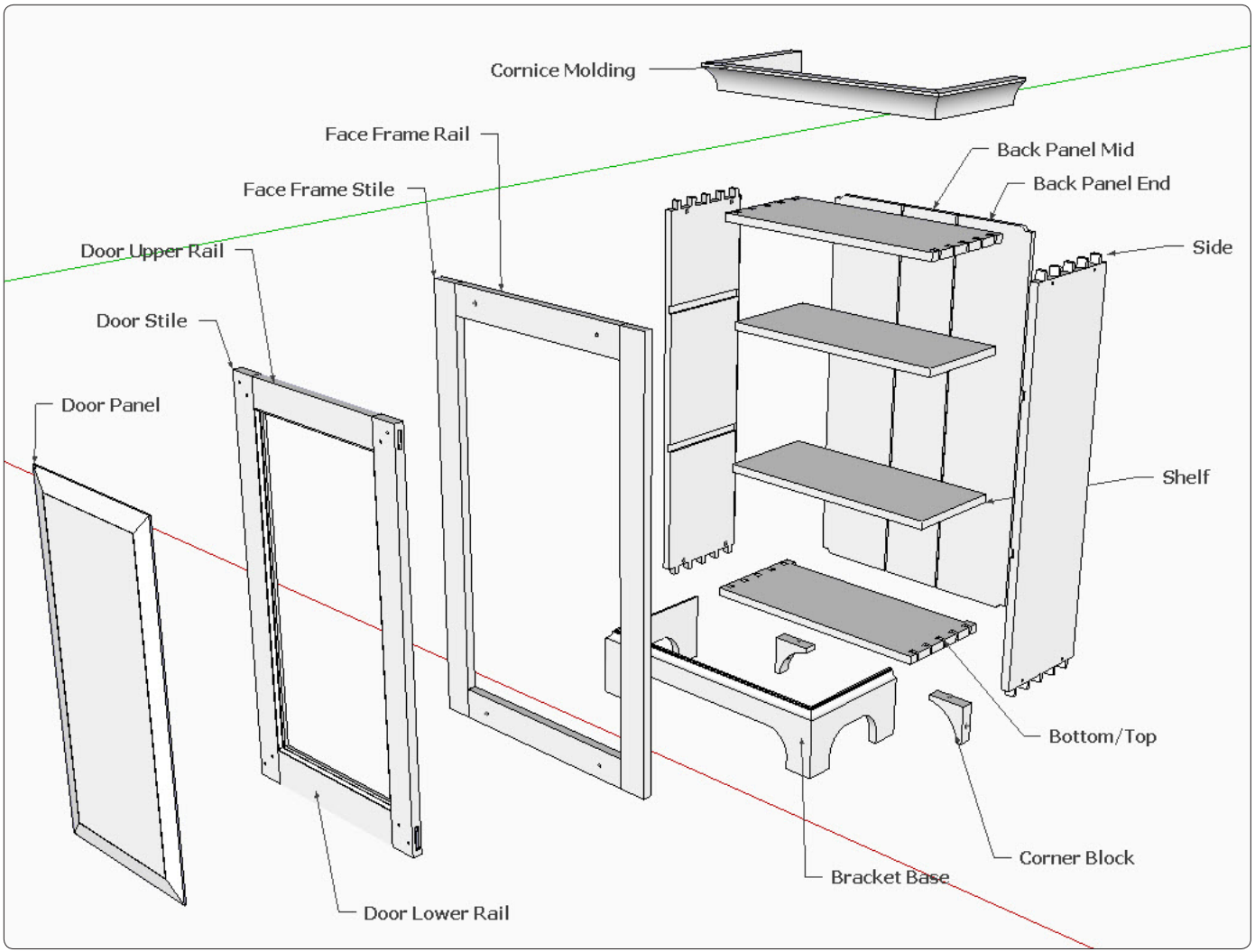


Figure 66. *An exploded view of the cupboard.*

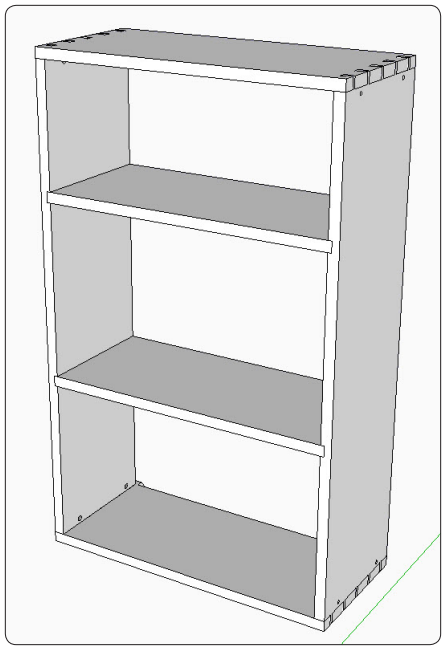


Figure 67. *The sides are dovetailed to the top and bottom, with shelves fitted into dadoes.*

Figure 65 is a measured orthographic drawing of the cupboard. Figure 66 is an exploded view. You can also refer to the original *Fine Woodworking* article for additional information.

Step 1 Construct the carcase, with dovetail joints at the corners and dadoes in the side components for the shelves. The top and bottom components are identical, which means that the four dovetail joints are identical, too. You need to draw only one, then copy it to the opposite ends of the boards. Figure 65 shows five evenly spaced pins in the joint, but feel free to modify the number of pins and their spacing. Figure 67 shows the finished carcase.

Step 2 Create the face frame in place over the carcase. Rough in the stiles and rails with no joint details, then give those components thickness and add the mortises and tenons. In Figure 68, I've reduced the opacity of the right stile so you can see through the face to the joint. Make the mortises and tenons whatever size you prefer.

Step 3 Create the bracket base. For this piece, it is 6 in. high, with the bottom of the carcase 3 ¾ in. from the floor. I made the bracket base as a single integrated

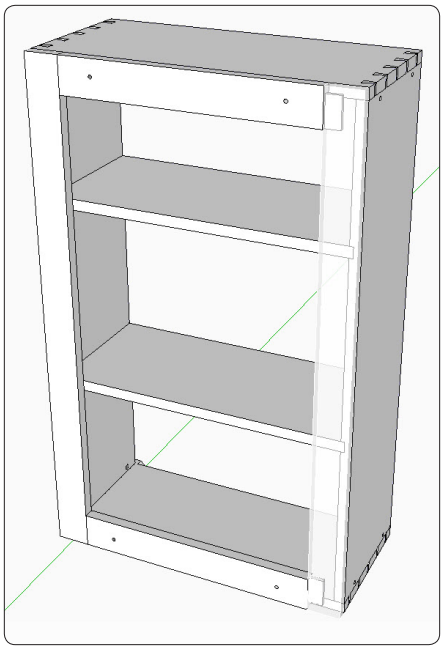


Figure 68. *Create the face frame, then add mortise-and-tenon joints.*

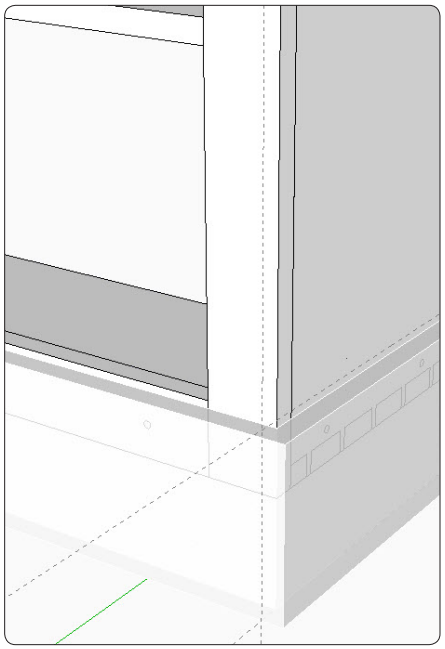


Figure 69. *Place guide lines and use them to properly position the bracket base.*

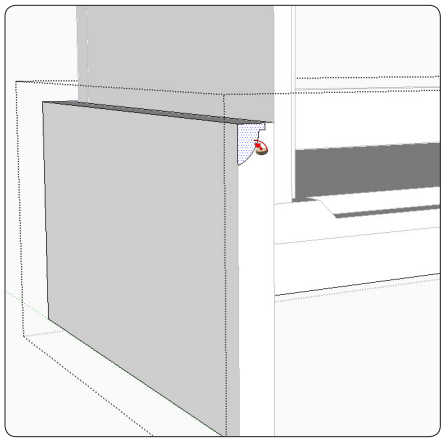


Figure 70. *Draw the molding shape, then use the Follow Me Tool to create the shape on all three sides of the base.*

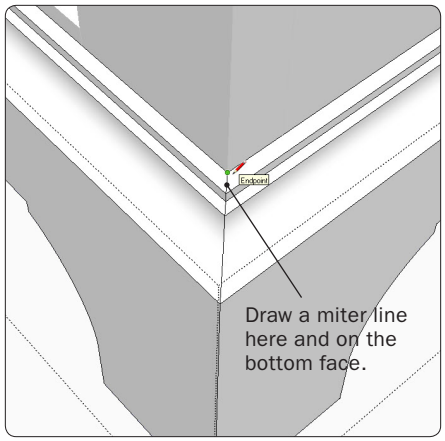


Figure 71. *Make a miter joint at the corners of the bracket base.*

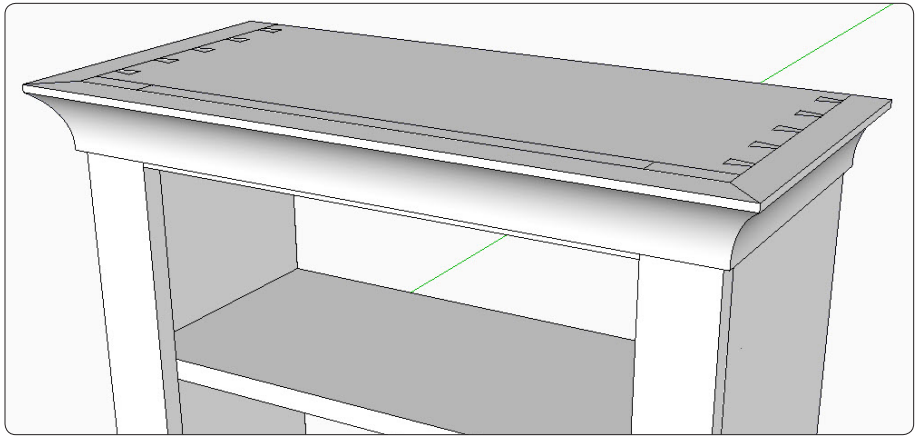


Figure 72. *Create the cornice molding just as you did the molding on the bracket base.*

component, without any seams or miter lines (Figure 69). That makes it easier to create the cove molding on the top edge. There are several ways to make the cutouts in the base. The magazine rack covered in Chapter 7 shows one method. Use the detail in Figure 65 as a guide for the shape of the cutout.

Create the molding shape with the Arc and Line Tools, using the detail in Figure 65. Place it on the back edge of the bracket base side. Select the top edge of the bracket base as a path for the Follow Me Tool. Select the Follow Me Tool and click on the face of the molding shape, as shown in Figure 70.

If you do want to break the bracket base into separate front and side components, you need to create miter joints at the corners. Use the Line Tool to create miter lines on the top surface of the joint and on the bottom face of the joint, as shown in Figure 71. This creates a face at the miter joint. Explode the component, select the graphics on one side to make a component, copy it for the second side, and select the front graphics to make the front component.

Step 4 Create the cornice much the way you did the bracket base. Use the Line Tool to create a square-shaped piece at the top of the front and sides of the case. Use the detail of the molding shape in Figure 65 as a guide to draw it on the flat rear face of the square. Then use the Follow Me Tool to create the shape. If you want to break it into separate pieces, draw miter lines at the corners, as explained in Step 3. The finished cornice is shown in Figure 72.

Step 5 The raised-panel door is the centerpiece of this SketchUp exercise. Figures 73–76 show dimensioned views of the joints, the door panel profile, and the molding profile on the stiles and rails. Print out those views to refer to as needed. Note the

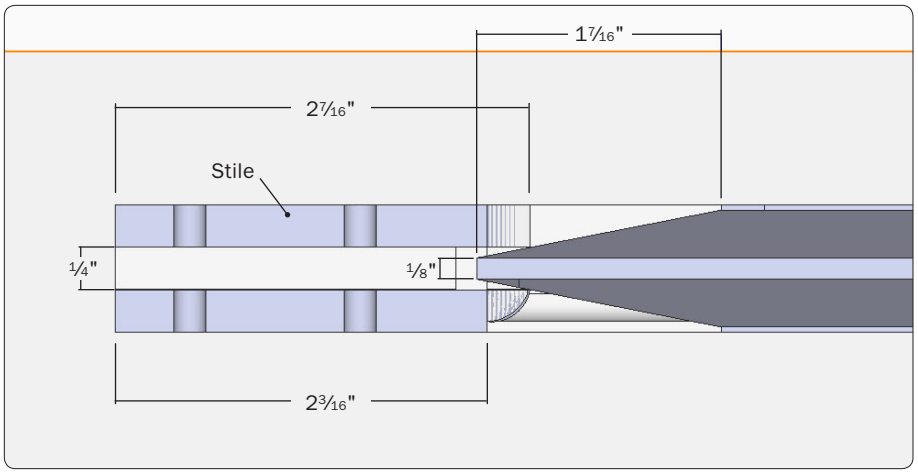


Figure 73. *Cross section, top view, of the left stile.*

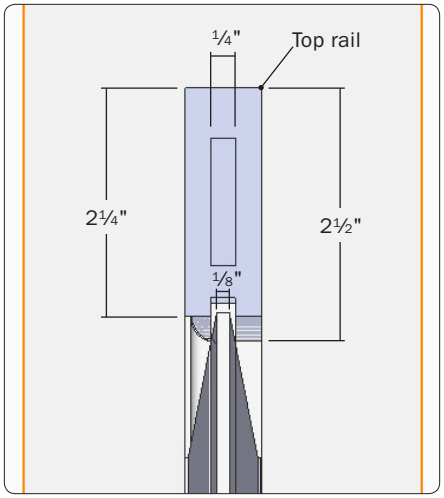


Figure 74. *Cross section, side view, of the top rail.*

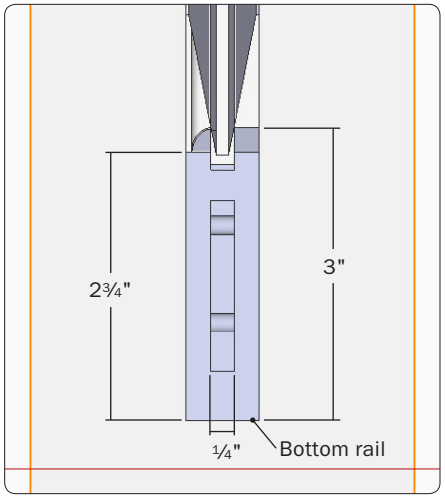


Figure 75. *Cross section, side view, of the bottom rail.*

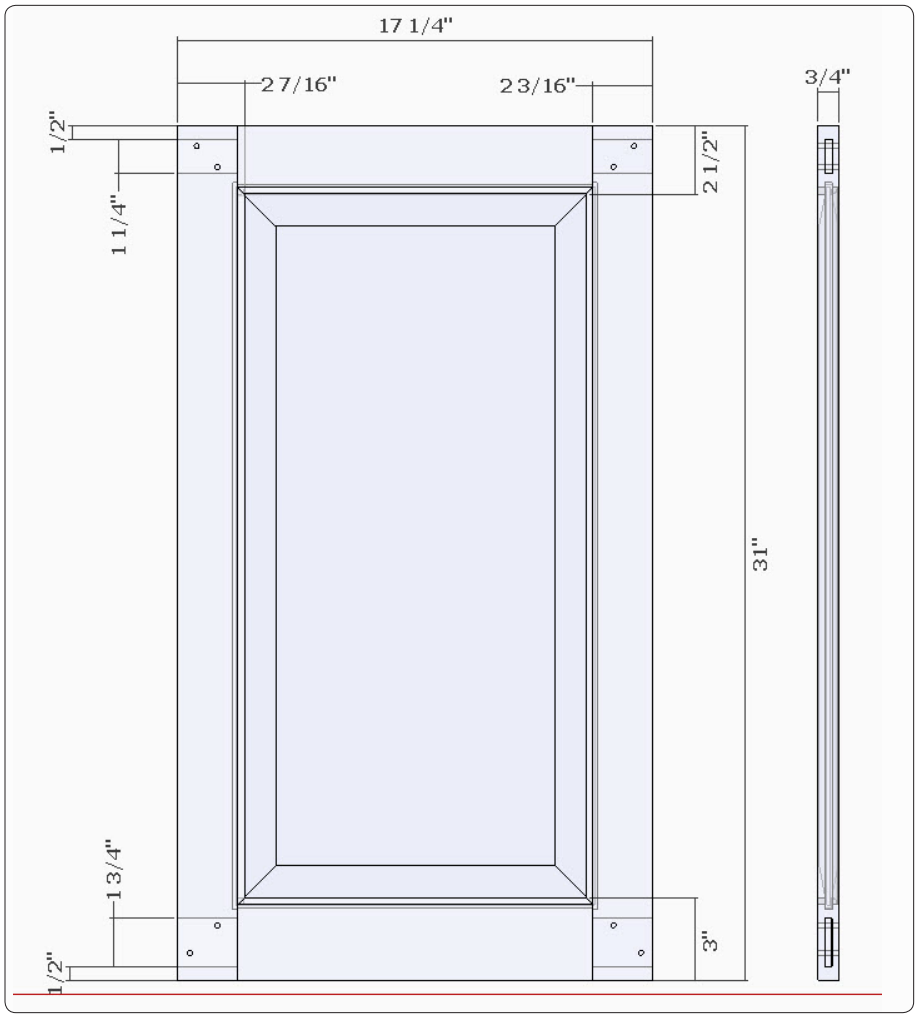


Figure 76. *Front and side views of the door.*

mitered molded inside edge of the rails and stiles.

Place guide lines to mark the widths of the stiles and rails. Rough them in, as shown in Figure 77, give them the proper thickness, and make them components.

Step 6 Copy the lower rail and move it away from the model to work on temporarily. Draw the shape of the thumbnail molding and the groove, as shown in Figure 78. Use the Push/Pull Tool to push each shape the full length of the rail. Do the same to make the thumbnail and groove in the stiles and upper rail.

Step 7 To make the mortises in the stile, place a guide line 2¼ in. down from one end of the stile. Then use the Push/Pull Tool, as shown in Figure 79, to remove ¼ in. of waste from the thumbnail profile and the back edge of the stile. Push the waste down to the guide line that is the width of the top rail minus the ¼-in. thumbnail, or 2¼ in.

In the shop, you would need to cut a stopped groove in the stile to

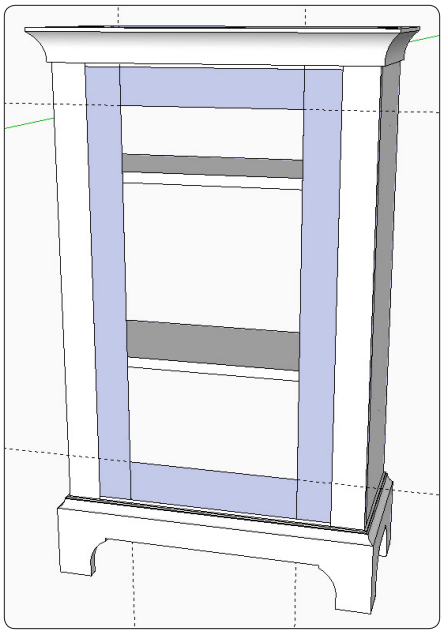


Figure 77. *Rough-in the stiles and rails.*

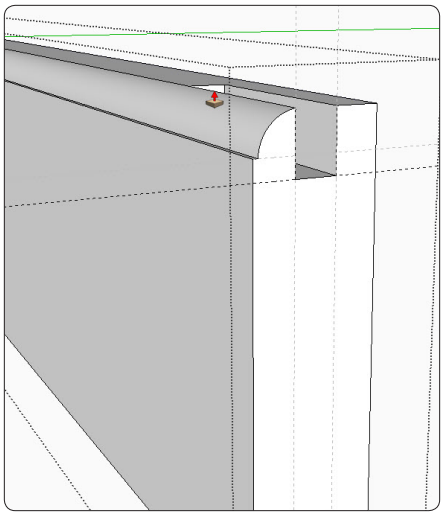


Figure 78. *Draw the thumbnail profile and groove in the stile, then push those shapes the full length of the component.*

avoid having a gap at the top end. In SketchUp, it's easier to run the groove through to the end, then backtrack, as shown in Figure 80. Place a guide line about ⅛ in. up from the end of the thumbnail. Draw a face as shown in Figure 81, then use the Push/Pull Tool to pull the bottom of the groove at the end of the stile flush with the inner face, as shown in Figure 82.

Place guide lines to show the length of the mortise and draw lines over them. Use the Push/Pull Tool to push the mortise through to the back edge of the stile. Delete unnecessary vertical lines.

Repeat these steps to draw the mortise at the opposite end of the stile. Check Figure 74 for the size of the mortise.

Step 8 Connect the top rail to the stile, as shown in Figure 83. In X-Ray View, use the outline of the mortise to create the tenon. (This procedure is explained in Chapter 7.) Copy the faces and edges of the tenon, execute a Flip Along command, and place the tenon on the opposite end of the rail. Repeat this step to make the tenons in the bottom rail.

Step 9 Use the Orbit Tool to move to the back side of the stile. Position the Protractor Tool at the corner, as shown in Figure 84, and draw a 45-degree guide line on the face. Trace over the guide line. Select the Push/Pull Tool and press the Ctrl key (Option on the Mac). A small + sign will appear on the cursor. Push the triangular shape beyond the front edge of the stile, as shown in Figure 85.

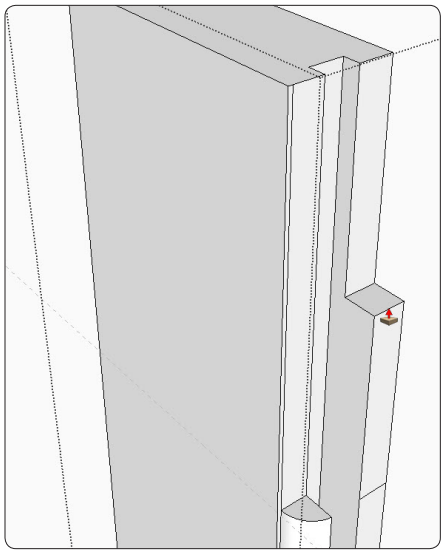


Figure 79. *Remove waste from the inside face of the stile.*

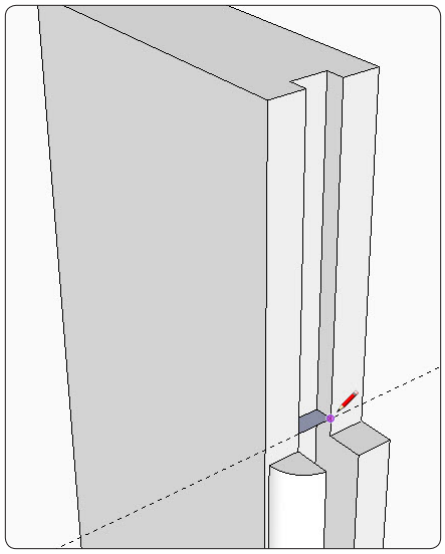


Figure 80. *Draw a face to mark the end of the stopped groove in the stile.*

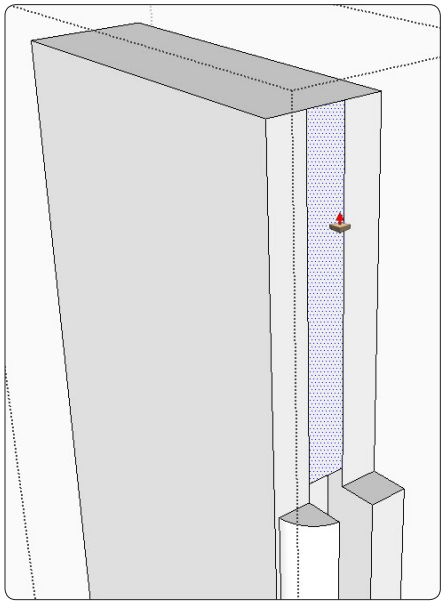


Figure 81. *Pull the end of the groove out to make it flush with the inside face of the stile.*

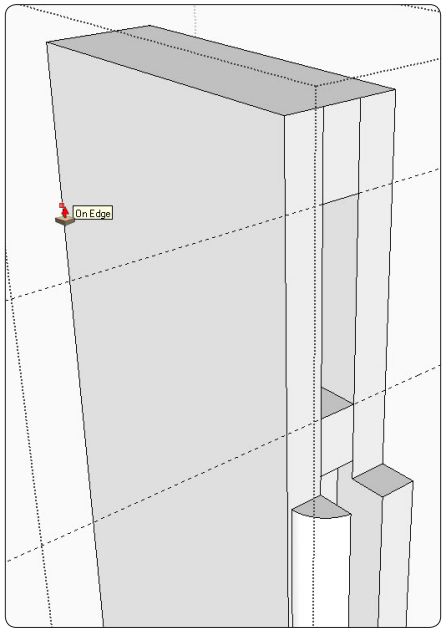


Figure 82. *Create the through mortise.*

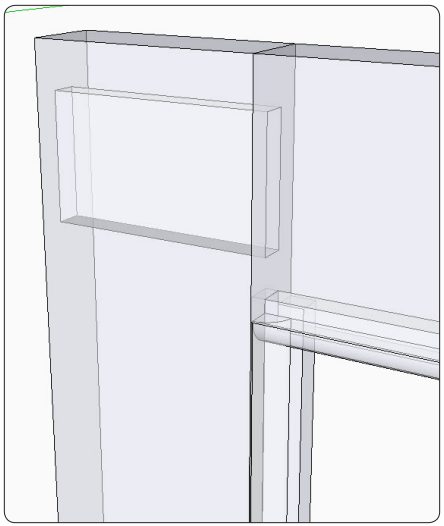


Figure 83. *Connect the top rail to the stile, and in X-Ray View use the mortise in the stile to shape the tenon in the rail.*

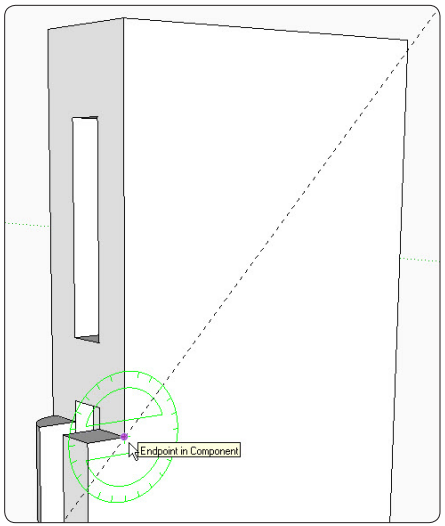


Figure 84. *Position the Protractor Tool as shown and draw a 45-degree guideline.*

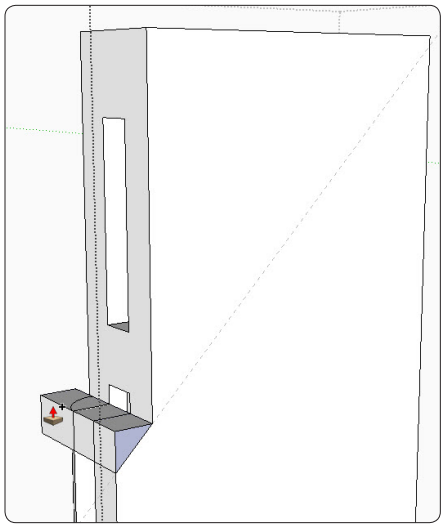


Figure 85. *Draw over the guideline, then push the triangular shape through the stile.*

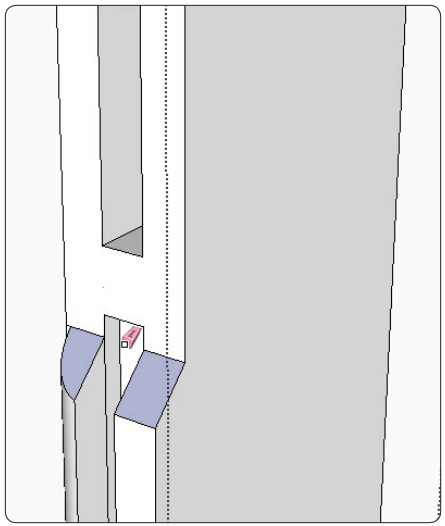


Figure 86. *Erase the waste, leaving this miter joint.*

Draw a left-to-right Selection Box around the miter joint. Right-click on the selection, and choose Intersect with Model from the pop-up menu. Use the Eraser Tool to clean up the waste, leaving the clean miter shown in Figure 86. Repeat this step to make the same joint on the other end of the stile and on both rails.

Step 10 There are many ways to make the raised panel. I'll show you what works for me.

Begin by drawing a face that just fits within the inner boundary of the door frame (Figure 87). Make the face a component. Copy the component and move it away from the model. Give the panel a thickness of ¼ in.

Use the Orbit and Zoom Tools and move to an upper corner of the panel.

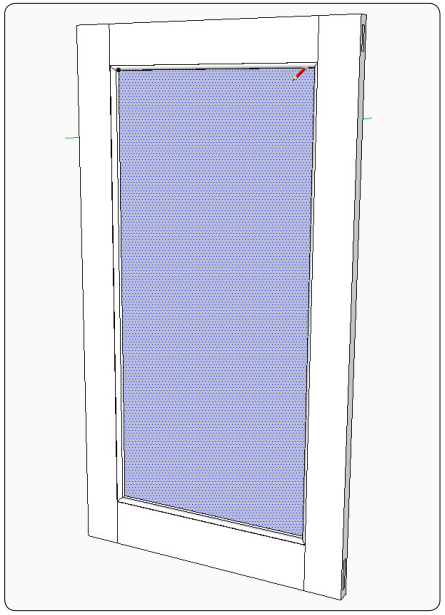


Figure 87. *Rough in the door.*

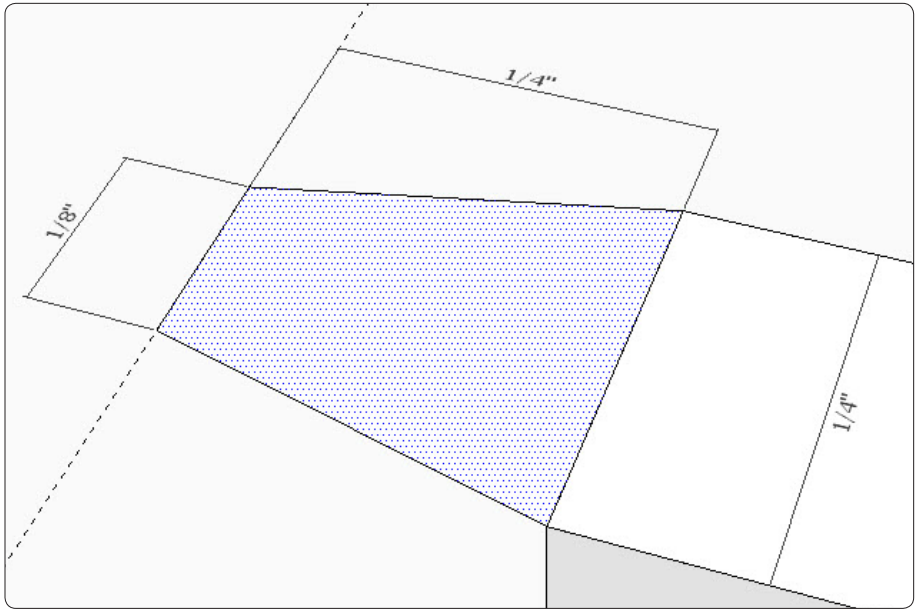


Figure 88. *Create a trapezoid shape that will be used to make the beveled edge of the door panel.*

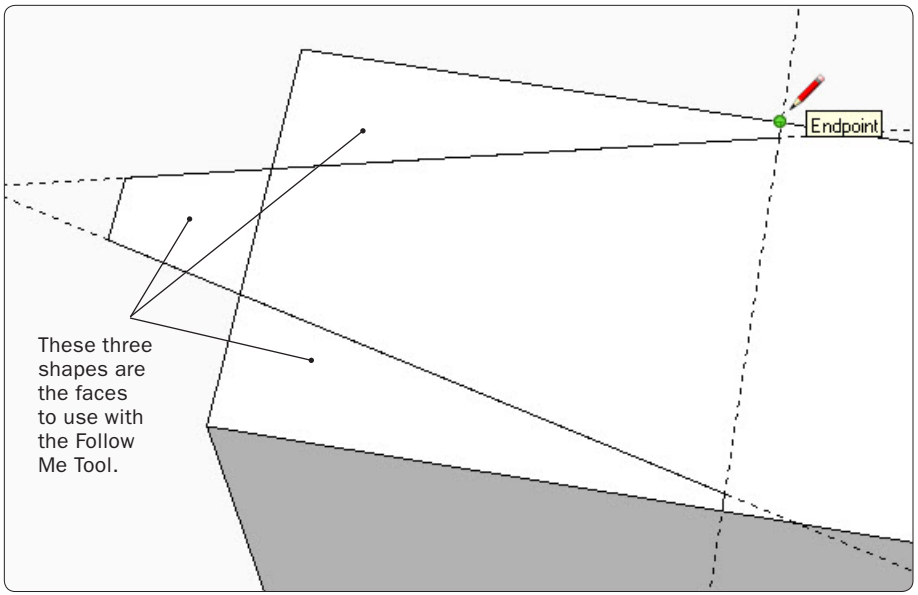


Figure 89. *Extend lines from the bevel over the door panel, creating three faces for the Follow Me Tool to use to make the bevels.*

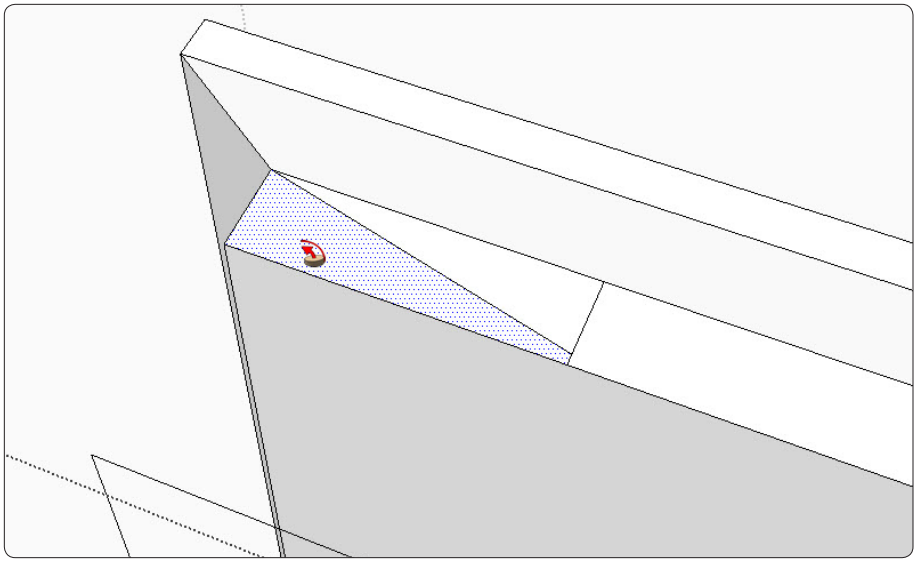


Figure 90. *Here, the tongue on the door panel has been shaped with the Follow Me Tool. The bevel on one face of the panel is ready to be shaped.*

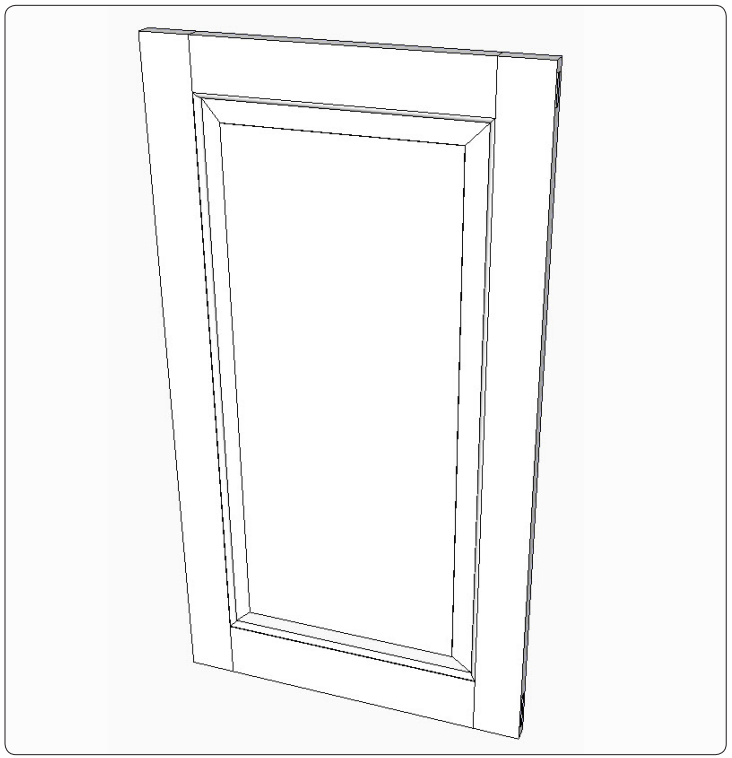


Figure 91. *The completed door.*

As Figure 88 shows, draw a trapezoidal shape, which will be used as a face for the Follow Me Tool, to make the beveled edge of the panel fitted into the groove in the door frame. Increase the panel thickness to ¾ in. by pulling out each face ¼ in.

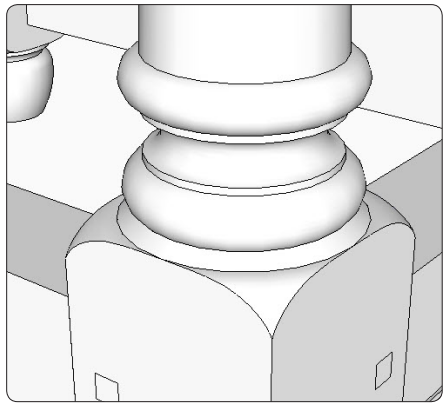
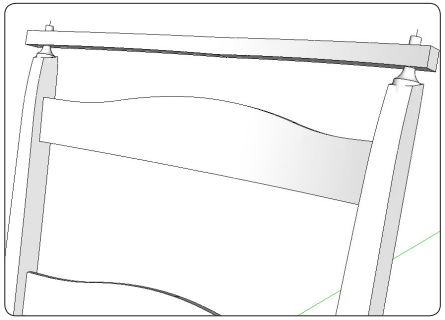
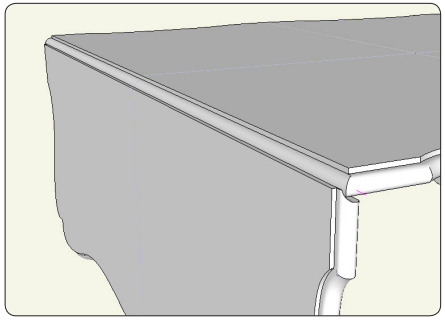
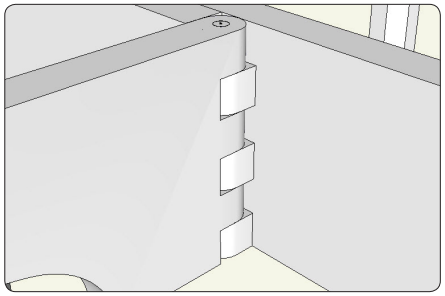
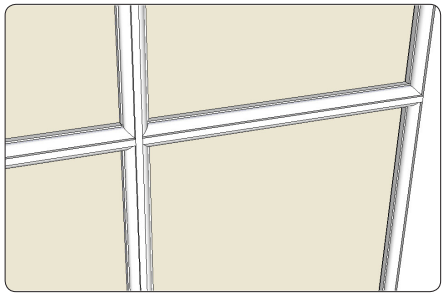
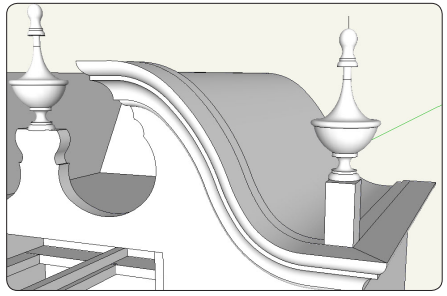
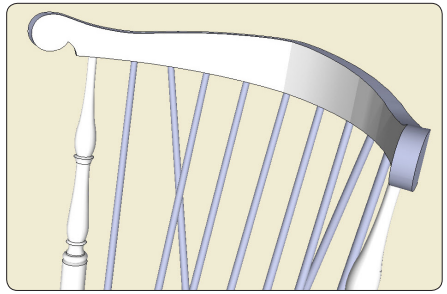
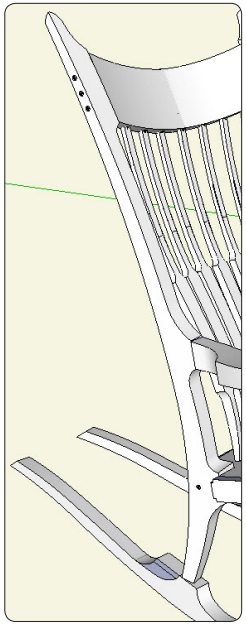
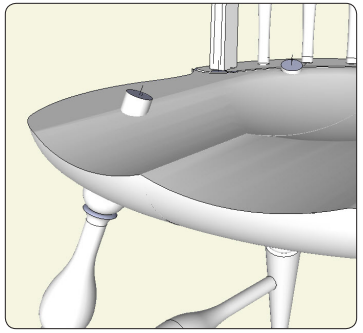
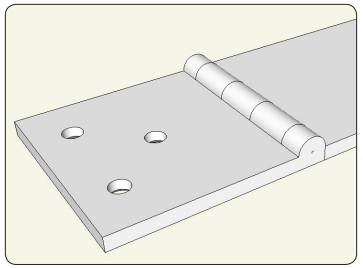
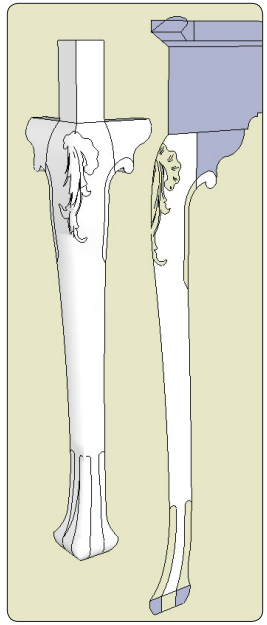
As Figure 89 shows, place guide lines over the sides of the trapezoid shape, and another guide line about 1/8 in. from where those guide lines intersect the edges of the door panel. Draw over the angled guide lines, as shown in the figure, and add a small line at each side to connect the angled lines with the edges of the panel. These small lines become a shoulder at the edge of the raised panel. The three shapes (one trapezoid and two triangles) serve as faces for the Follow Me Tool.

Step 11 Create a path for the Follow Me Tool that is the same size as the door panel. Copy the edges and move them away from the model. Select the path, then select the Follow Me Tool and click on one of the three faces shown in Figure 89. Repeat for the remaining two faces. Figure 90 shows the results from two of the Follow Me executions. Use the Eraser Tool to remove any extraneous lines on the faces of the panel. Figure 91 shows the completed door.

Advanced Detail Modeling Using the Intersect Command

As my SketchUp skills improve, I find that I can take on more challenging furniture projects in the shop. Developing a SketchUp model gives you an understanding of the details involved in actual shop work. And, of course, the devil is in the details. You can create a pretty picture in SketchUp, a pseudo-model lacking complete content. But it's far better to create a model that includes all the furniture components along with the joint details, molding profiles, and surface ornament. It's those small details that can bedevil you. So, in this chapter, I'll explain how to create an array of challenging furniture shapes and parts:

- A pommel, or square-to-round transition on a turned leg.
- A bonnet for a highboy.
- A curved crest rail for a chair.
- A curved back slat for a chair.
- A rule joint for a tabletop.
- A wooden hinge for a drop-leaf table support.
- Mullion and muntin joints for a window or glass door.
- The back leg on a Maloof-style rocker.
- A sculpted seat for a Windsor chair.
- A carving.
- A small cabinet hinge.

I will show how to create these elements on 18th-century and Shaker styles, but the techniques apply to any period or style. The 11 projects in this chapter won't cover every difficult situation you may face, but they show you techniques you can adapt for other situations.

These projects have one thing in common: They all make use of SketchUp's Intersect Faces command. I introduced this in Chapter 10, showing how to use it to shape a cabriole leg. Here, I'll show how it can be used to create mitered joints, a return on a curved molding, hinges, and more. Intersect Faces is also used to clean up areas where two different molded shapes intersect.

How to Add a Pommel to a Turning

Turned legs and stretchers often have a pommel: a square section where mortises or dowel joints can be placed. The Connecticut stool shown in Figure 1 has two pommels on its legs. The challenge, in SketchUp as well as actual lathe work, is to make the transition from the round portion to the square shape. This transition is sometimes an ogee curve, but in this case it is a simple rounded shape, as shown in Figure 2. Creating the transition in SketchUp entails intersecting shapes, then removing the waste. Here's what to do.

Step 1 Print out Figure 11 from Chapter 11, scan it, and import it into SketchUp. Scale the image and trace over it to create the flat-face shape of the turned leg, including the square sections (Figure 3).

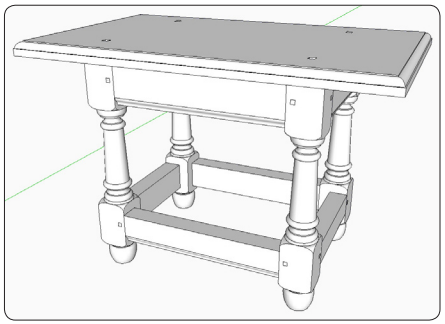


Figure 1. *The square sections on turned legs are challenging in SketchUp and at the lathe.*

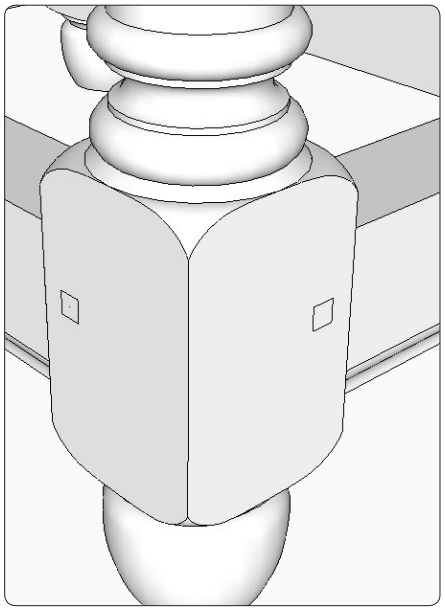


Figure 2. *The biggest challenge is making the transition from square to round. The plain curve shown here is the simplest type of transition.*

Step 2 Use the Follow Me Tool to create the turned sections of the leg. Leave the rectangular shapes of the pommel as flat faces, as shown in Figure 4.

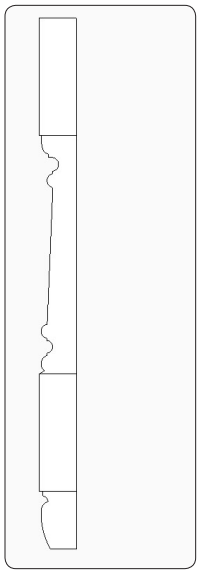


Figure 3. *Import a drawing of the leg and use it to create the flat face shown here.*

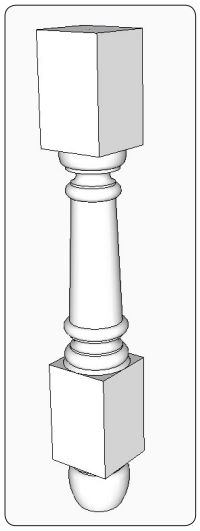


Figure 5. *Give the pommels their full shape.*

Step 3 Use the Push/Pull Tool multiple times to make the rectangular faces into square sections, as shown in Figure 5.

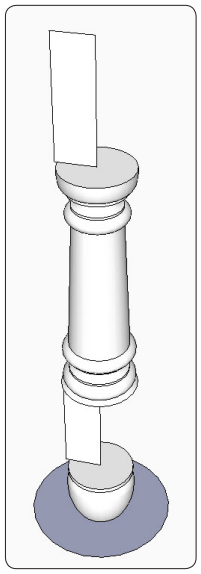


Figure 4. *Create the turned sections, but leave the pommels as flat faces.*

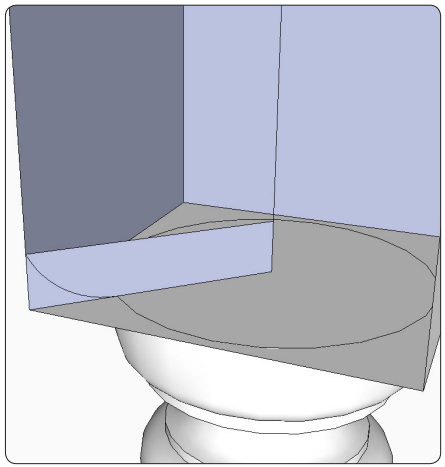


Figure 6. *Hide one face of the pommel, then create the transition shape along the diagonal.*

Step 4 Right-click on the front face of the upper pommel and select Hide from the pop-up menu. This will let you view the inside of the pommel.

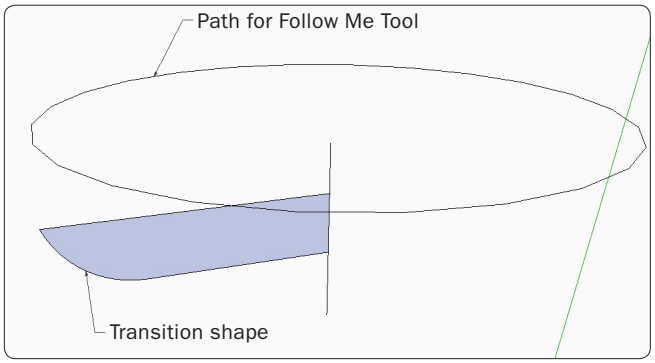


Figure 7. *Move the transition shape away from the model and create a path for the Follow Me Tool.*

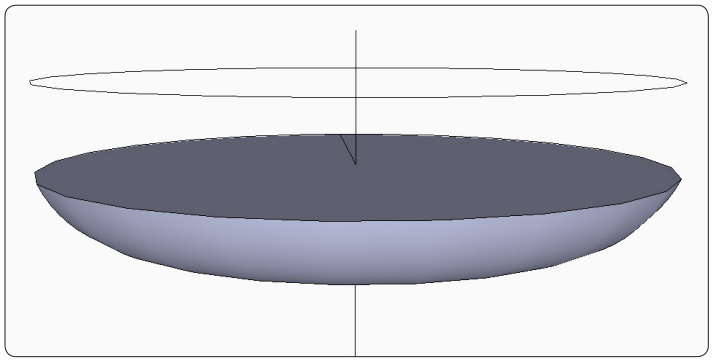


Figure 8. *The resulting shape is a transition cutter.*

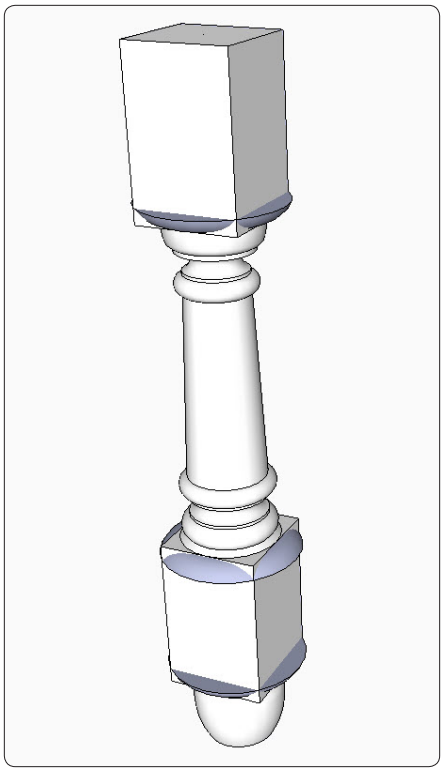


Figure 9. *Move copies of the transition cutter into position at the ends of the pommels.*

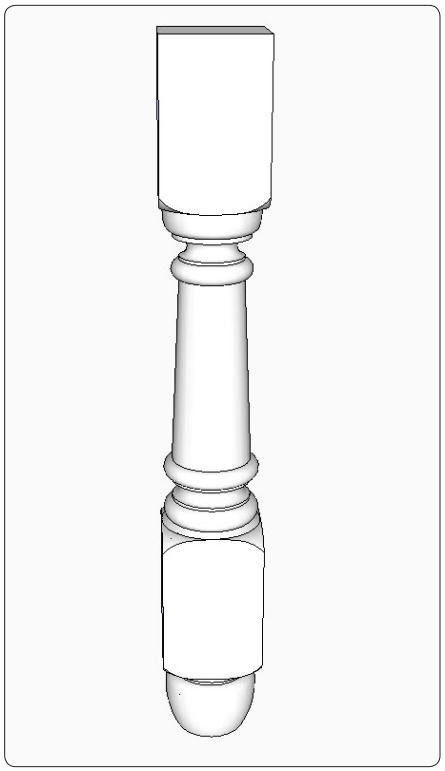


Figure 10. *The completed leg, pommels, and transitions.*

Create a diagonal rectangle from the center of the pommel, then use the Arc Tool to draw the transition shape, as shown in Figure 6. You can use the imported drawing of the leg to determine the height of the transition shape.

Step 5 Copy the transition shape and move it away from the leg. Add lines to extend the side that will become its center and draw a circular path for the Follow Me Tool (Figure 7). Executing the Follow Me command produces what I call the *transition cutter* shown in Figure 8.

Step 6 Use the Move/Copy Tool to precisely position copies of the transition cutter into the appropriate locations on the leg turning, as shown in Figure 9. Flip the middle cutter along the blue axis to orient it properly.

Step 7 Explode any components or groups you have made, select all of the leg, including the transition cutters, and use the Scale Tool to scale up the size by a factor of 10. Right-click on the selected leg and choose Intersect Faces with Selection from the pop-up menu. Use the Eraser Tool to remove the extraneous fingernails from the transition cutters, leaving smooth transitions at the ends of the pommels. Select the entire leg, right-click, and select Make Component from the pop-up menu. Select the component and use the Scale Tool with a factor of 0.10 to bring it back to full size. Figure 10 shows the completed leg.

How to Make a Bonnet with Gooseneck Molding

Here's the process I have used to create a bonnet and curved gooseneck molding for a highboy. Figure 11 shows the highboy case and an exploded view of the bonnet.

I'll show you the steps involved, but not the illustration I used as a source. You can take shapes and measurements from whatever sources you use to create your own highboy.

Step 1 Use the Line and Arc Tools to develop the shape of the molding. The profile I used is shown in Figure 12. Connect the molding shape to the back edge of the highboy's carcase side, as shown in Figure 13.

Step 2 Create the path for the Follow Me Tool, connecting the curved portion to the front of the carcase side, as shown in Figure 13. I was able to trace the path from a scanned image using the Arc Tool. This includes the curved section and the outside top edge of the carcase

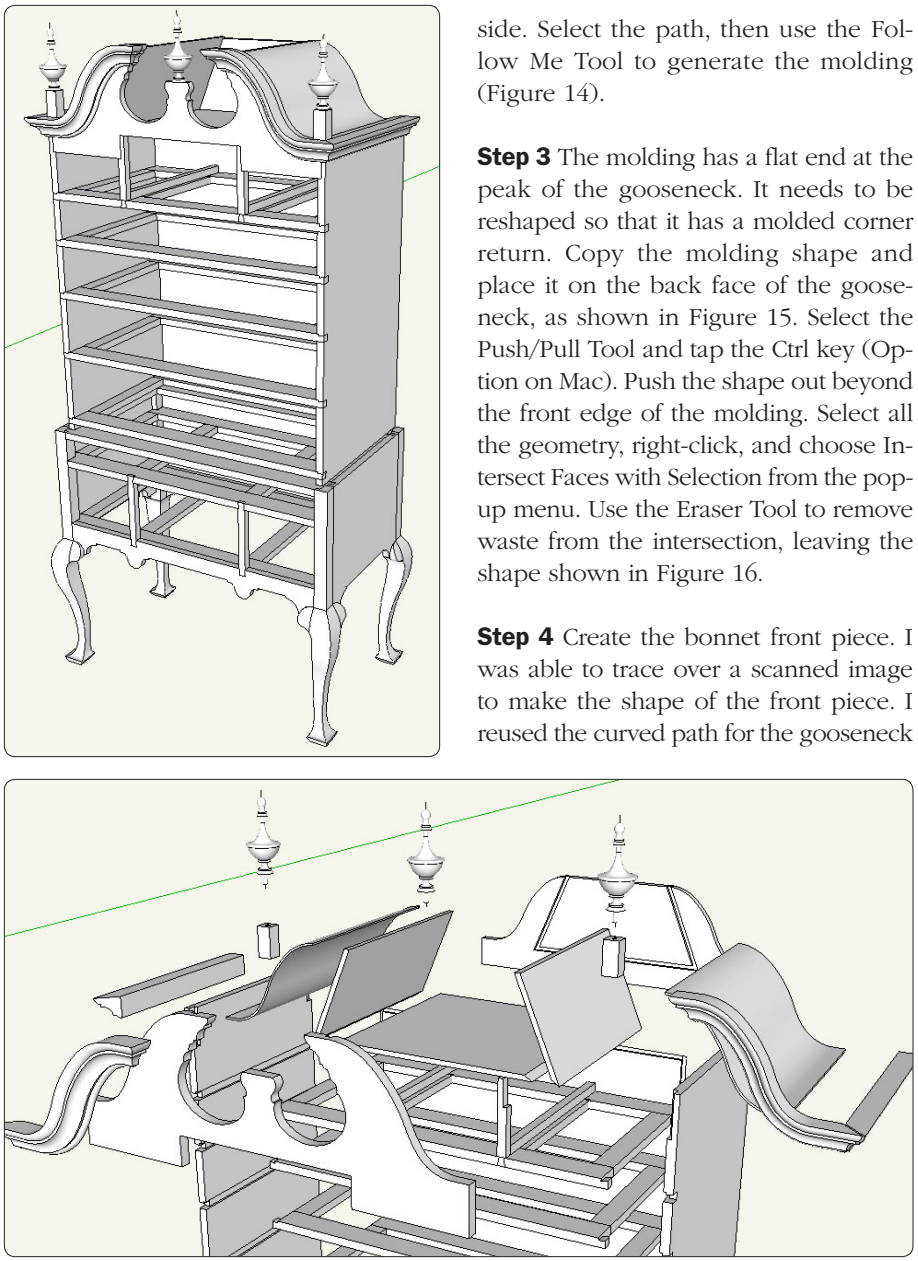


Figure 11. *The case for the American highboy and an exploded view of its bonnet.*

side. Select the path, then use the Follow Me Tool to generate the molding (Figure 14).

Step 3 The molding has a flat end at the peak of the gooseneck. It needs to be reshaped so that it has a molded corner return. Copy the molding shape and place it on the back face of the gooseneck, as shown in Figure 15. Select the Push/Pull Tool and tap the Ctrl key (Option on Mac). Push the shape out beyond the front edge of the molding. Select all the geometry, right-click, and choose Intersect Faces with Selection from the pop-up menu. Use the Eraser Tool to remove waste from the intersection, leaving the shape shown in Figure 16.

Step 4 Create the bonnet front piece. I was able to trace over a scanned image to make the shape of the front piece. I reused the curved path for the gooseneck molding to duplicate the ogee curve. Once you have drawn the shape and given it the proper thickness, make it a component. Use the Move/Copy Tool to connect it with the top rear corner of the gooseneck molding, as shown in Figure 17.

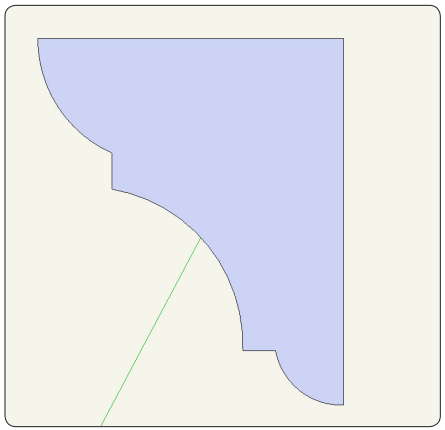


Figure 12. *The profile for the gooseneck molding.*

Step 5 Use the Orbit Tool to move around to the back side of the bonnet front. Place guide lines as needed and use the Line and Push/Pull Tools to create the grooves that hold the inner enclosure of the bonnet (Figure 18). If you're working from a detailed plan or drawing, follow it for the width, depth, and angle of the grooves.

Step 6 Use the Line and Push/Pull Tools to create the three inner enclosure pieces, as shown in Figure 19.

Step 7 Use the Offset Tool to make the curved bonnet top. (This tool, found just under the Follow Me Tool in the large tool set, is one I rarely use. It makes

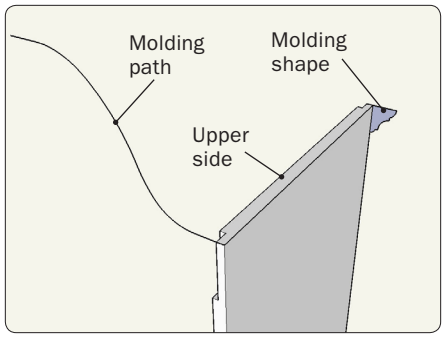


Figure 13. *Attach the molding shape to the carcase side, then draw the ogee curve path for the Follow Me tool.*

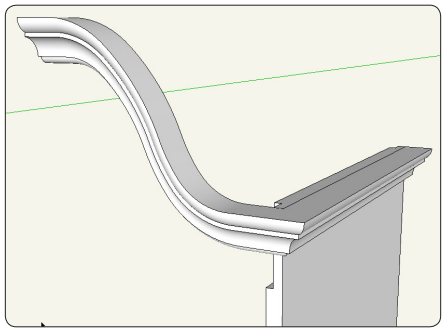


Figure 14. *The molding for half the bonnet, with a few details remaining.*

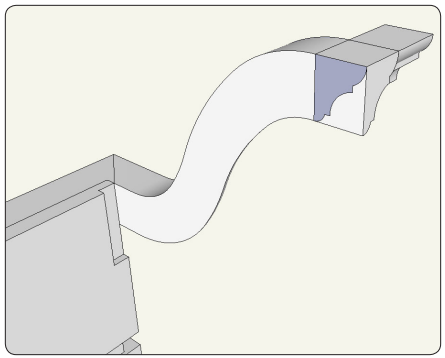


Figure 15. *Copy the molding shape and place it on the rear of the gooseneck. Then push it through to intersect the gooseneck.*

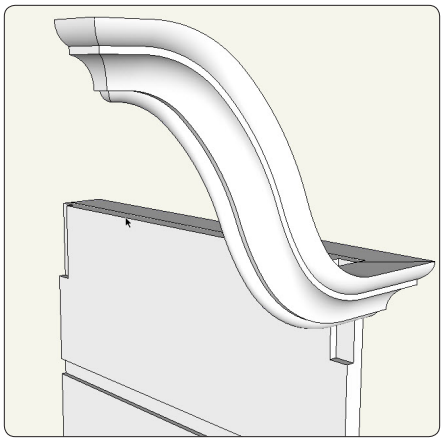


Figure 16. *Once you remove the waste, you will have a gooseneck molding like this.*

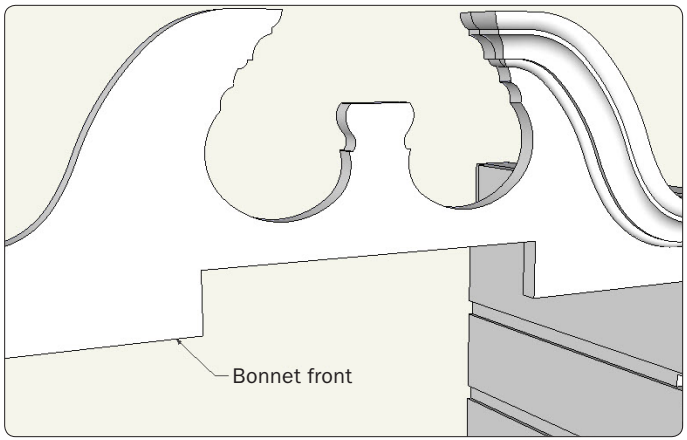


Figure 17. *Create the bonnet front piece and connect it to the gooseneck molding.*

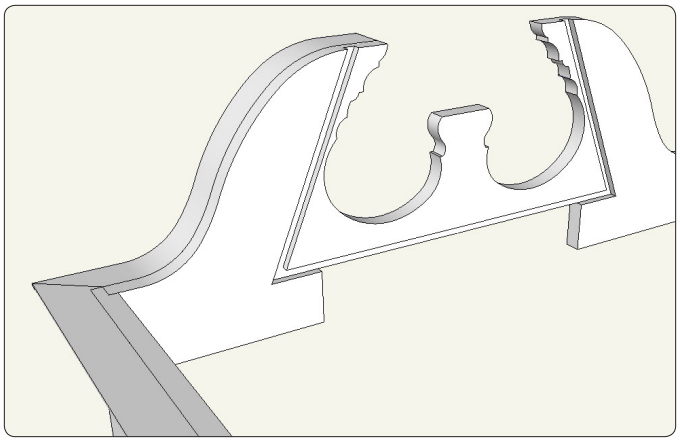


Figure 18. *Create grooves on the rear face of the bonnet front to hold the pieces for the inner enclosure.*

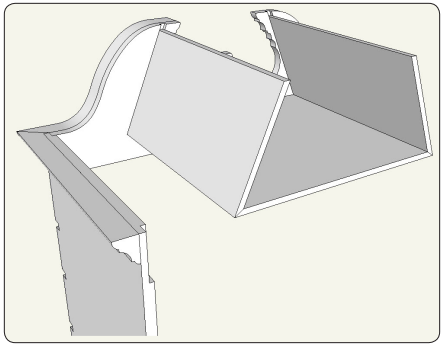


Figure 19. *Make the inner enclosure pieces.*

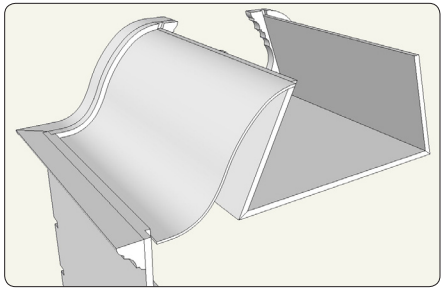


Figure 20. *Use the Offset Tool to create an edge of the curved bonnet top, then use the Push/Pull Tool to make it the proper depth.*

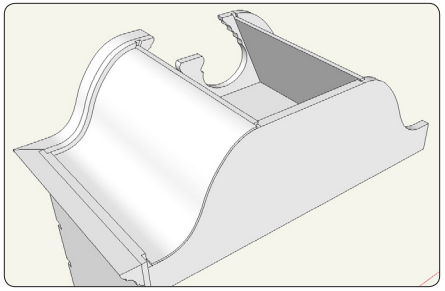


Figure 21. *The bonnet back in place. This part of the highboy is complete, except for the decorative finials.*

a copy of a line exactly parallel to the original.) With the Offset Tool, click on the top edge of the bonnet front; you'll see a red square on the line. Hold the mouse and move the cursor; you'll see the copied line appear and move with the cursor. Move the copy down about ½ in. Use that shape to create the curved bonnet top, as shown in Figure 20. You may need to draw some additional lines to be sure that the copied curve joins with the sides of the shape so that you have a face to use.

Step 8 Use the bonnet front to create the bonnet back. Copy the front, flip it, make it unique, eliminate the center cutout, and move it in place. When you move it into position, be sure the curved bonnet top is fastened to the top edge of the bonnet back. Figure 21 shows the bonnet back in place.

How to Make a Curved Crest Rail

I'll show you how to create the crest rail for the Philadelphia fan-back Windsor chair shown in Figure 22. Shaped, curved crest rails similar to this exist on chairs from many styles and periods. The rail is often steam bent, so you need to know the actual length of the blank rail before it's bent. After explaining how to draw the curved rail, I'll show you how to "unbend" it using a plug-in, so you can measure its actual length.

Whenever I want to reproduce a chair's top rail, I look for a front and top view of the chair to obtain the necessary shape information. I scan these views and import them into SketchUp for tracing over.

Step 1 Use the Line and Arc Tools to trace over the front and top views, as shown in Figure 23. Because the rail is symmetrical, you need to trace only half of each view. Be sure to include hole spacing for spindles or socket holes.

Step 2 Use the Push/Pull Tool to make the top view shape about 4 in. tall. The exact height isn't important, as long as it's greater than the height of the front view. Rotate this shape to coincide with the angle of the reclining back of the chair. Then position guide lines as shown in Figure 24 to help push the front shape through the canted rail.

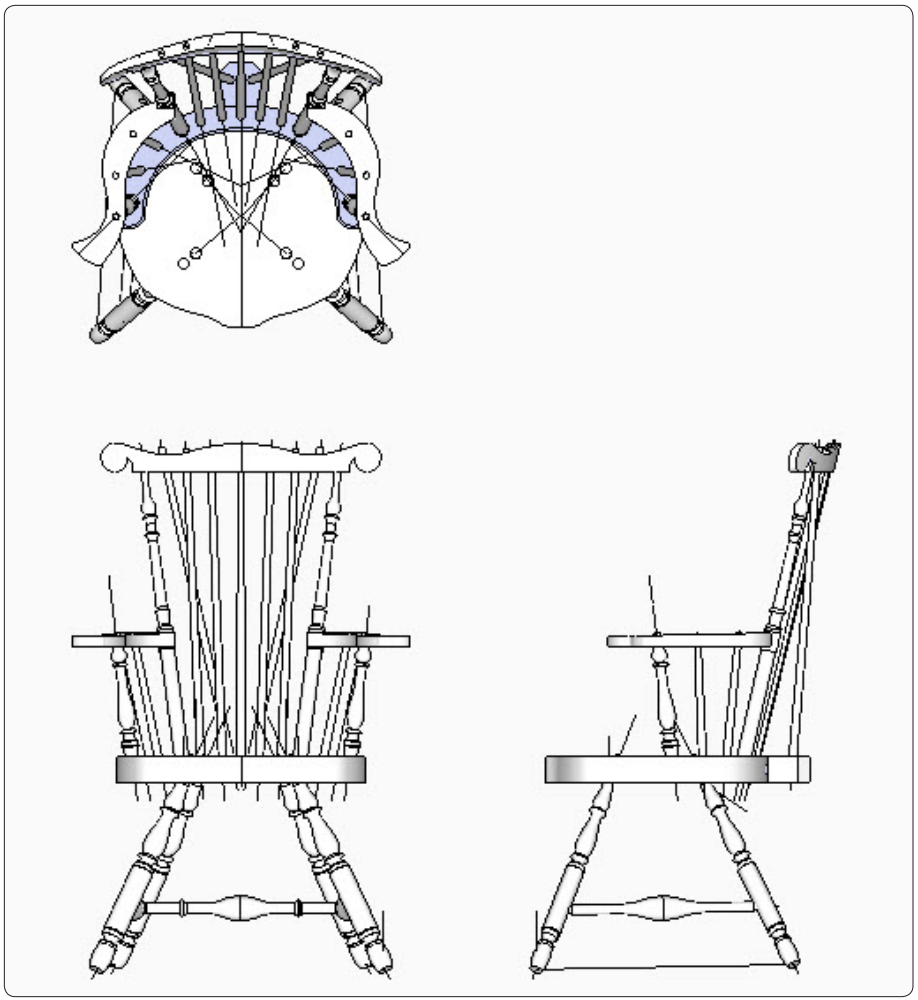


Figure 22. *A fan-back Windsor chair with a steam-bent crest rail.*

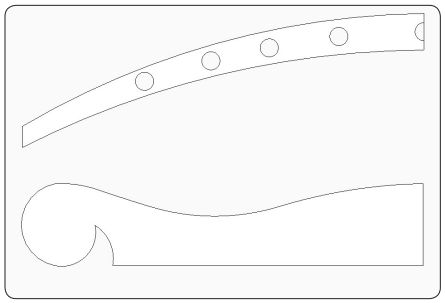


Figure 23. *The front and top of the crest rail, traced from an imported image. Trace overs of the front and top views of the top rail*

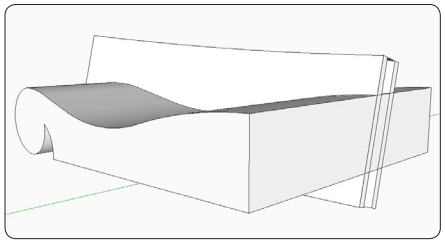


Figure 25. *Push the front shape through the top shape, select everything, then use the Intersect Faces with Selection command.*

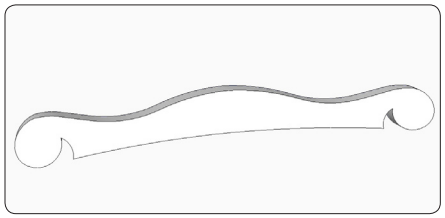


Figure 27. *The completed crest rail, properly bent and angled.*

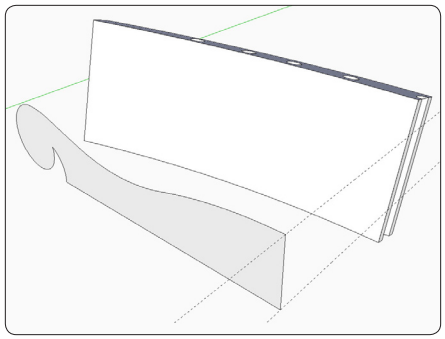


Figure 24. *Give the top view ample height and angle it to match the angle of the chair. Position the other view in front of the top view.*

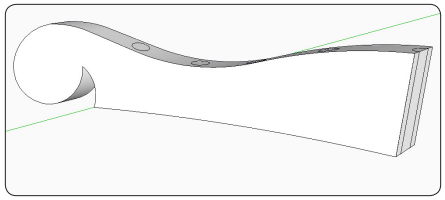


Figure 26. *The top rail after the two shapes have been intersected and the waste removed.*

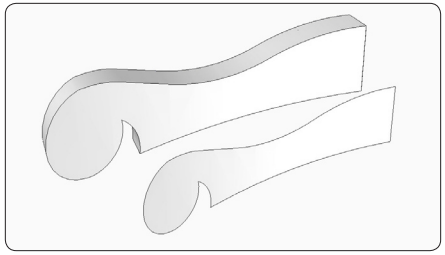


Figure 28. *Select the front face of the half rail and make it a component.*

Step 3 Use the Push/Pull Tool to extrude the front shape through the top shape. Select all the graphics, right-click, and choose Intersect Faces with Selection from the pop-up menu (Figure 25). Use the Eraser Tool to remove waste, yielding the half-rail shape shown in Figure 26.

Step 4 Copy the half rail, execute a Flip Along command, and use the Move/Copy Tool to join the two shapes at the middle. To hide the centerline, use the Eraser Tool while you press the Shift key. Figure 27 shows the completed crest rail.

Step 5 To determine the "flattened" shape and length of a rail that will be steam bent, work with the half shape created in Step 3. Double-click on the front face of the shape to select the face and bounding edges. Right-click on the selection and choose Make Component from the pop-up menu (Figure 28).

Step 6 There is a tedious manual way to unfold and flatten the curved shape. But I find it much more productive to use the Unfold plug-in (available at

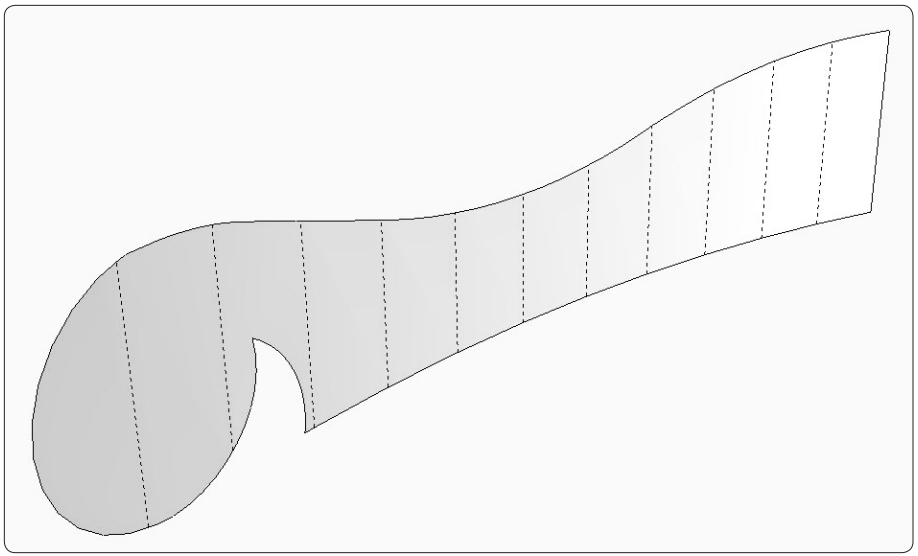


Figure 29. *Turn on Hidden Geometry, which divides the rail into segments, in preparation for using the Unfold plug-in.*

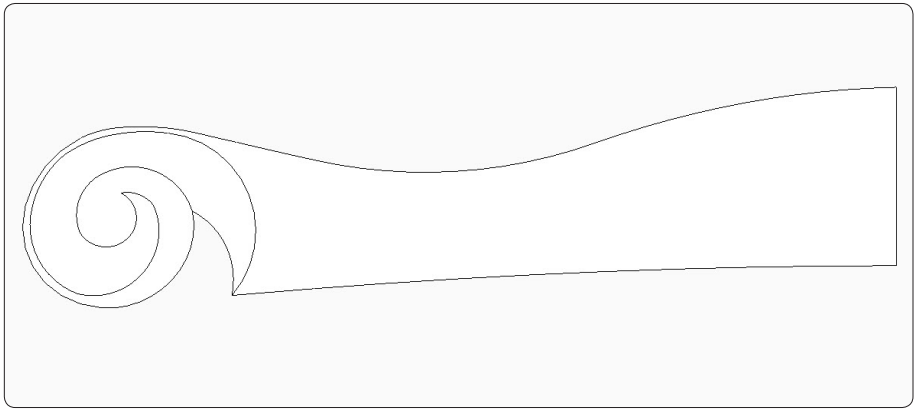


Figure 30. *The full-size template for the crest rail, with the volute carving drawn at the end.*

http://sketchuptips.blogspot.com/2007/08/plugin-unfoldrb.html). Here's how to use the plug-in once you have downloaded it.

Turn on Hidden Geometry under View in the Menu Bar, which displays the segments of the rail, as shown in Figure 29. Click on Plugins in the Menu Bar and choose Unfold. Click the mouse on each segment in sequence. Each click of the mouse realigns a segment into a straight flat component.

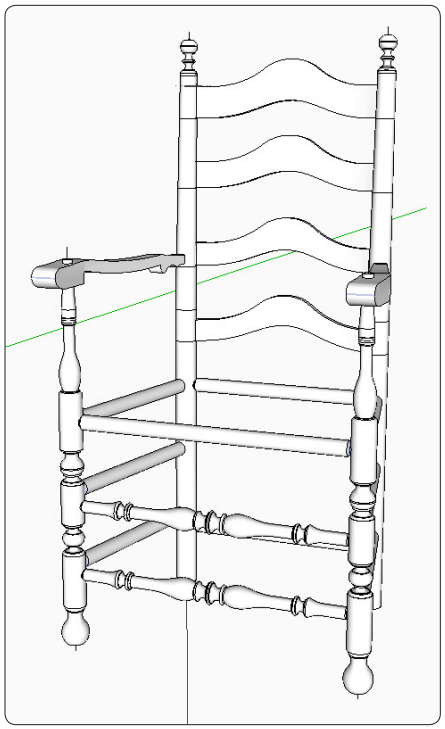


Figure 31. *This 18th-century Connecticut armchair has back slats that make for a challenging SketchUp exercise.*

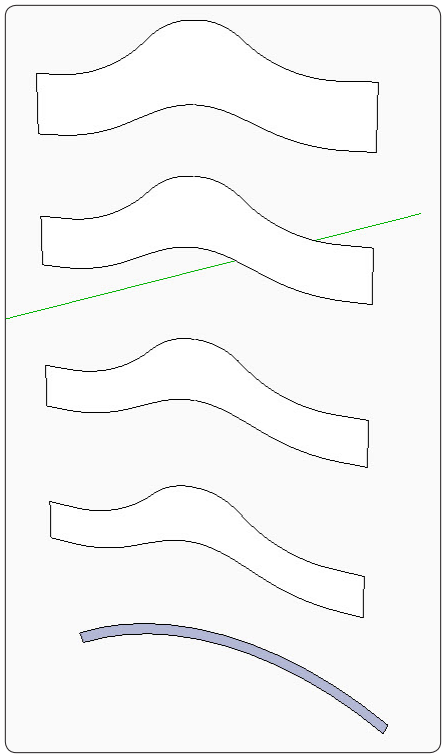


Figure 32. *Trace over the front and top views of each slat.*

Step 7 Create the full-size template for marking out the blank lumber in preparation for steam bending. Set the camera to Parallel Projection and Front View and print the template. You can add the volute carving with the Arc Tool, as shown in Figure 30. I typically add the carving details to mark the bent top rail in preparation for carving

Creating Back Slats

Back slats are beautifully demonstrated in the 1730s Connecticut ladderback arm chair shown in Figure 31. Each slat is slightly different from the others, and each has curves in all directions. Curved slats are part of many styles, including Morris chairs, art deco, and Shaker.

I was fortunate to find a rough sketch of the chair that included front, top, and side views. I scanned the sketch into SketchUp and scaled it to full size. You'll need similar views for your own chair designs.

Step 1 Use the Line and Arc Tools to trace over the shapes from the front and trace one top view, as with the chair

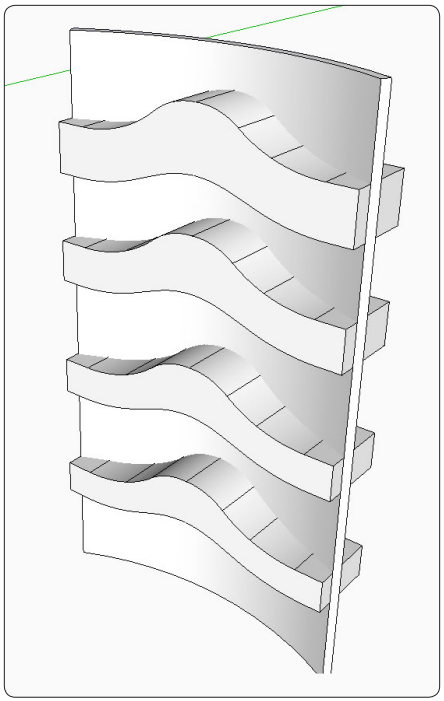


Figure 33. *Use the Push/Pull Tool to give the slats thickness, and pull the top view up to intersect with all the slats.*

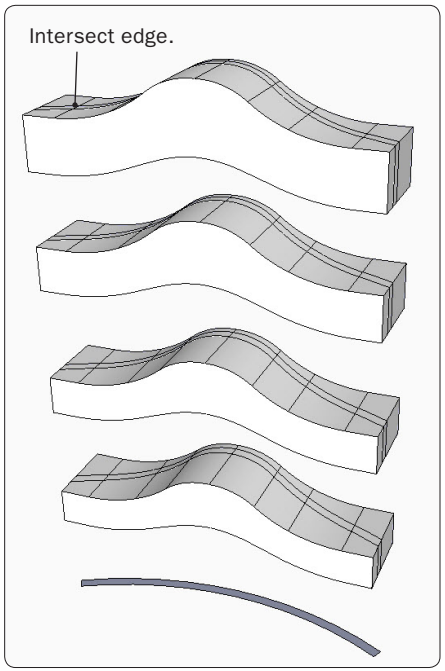


Figure 34. *Intersect all the extruded shapes, then begin removing the waste. You will soon see the "intersect edges," which identify the shaped slats.*

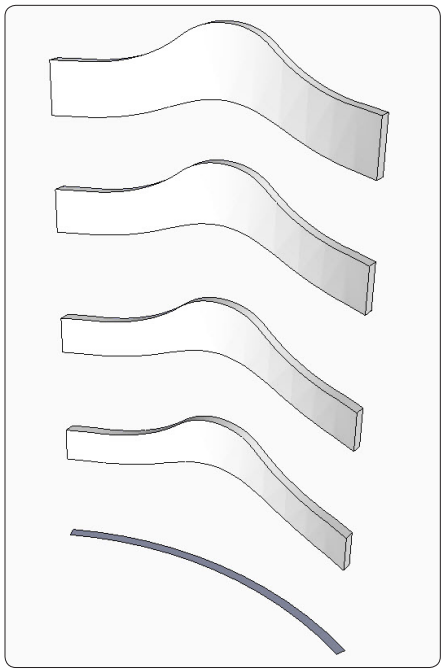


Figure 35. *Clean up the remaining waste to expose the finished slats.*

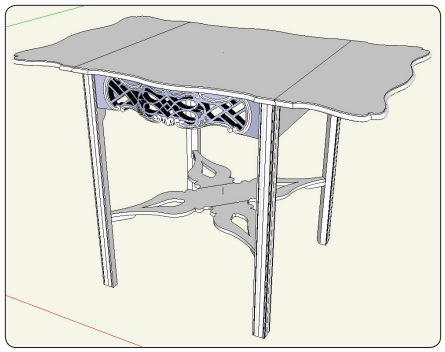


Figure 36. *This breakfast table has rule joints on the main top and leaves.*

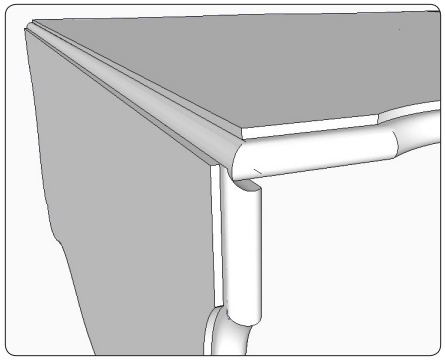


Figure 37. *A close-up view of the rule joint.*

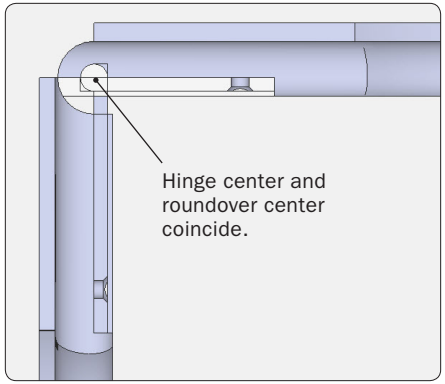


Figure 38. *A cross section of the rule joint through the hinge.*

crest rail in the previous exercise. Keep the slats oriented and spaced as they are in the finished chair (Figure 32).

Step 2 Use the Push/Pull Tool to give the front view of each slat thickness; the exact amount doesn't matter, but be generous. Then use the Push/Pull Tool to give the top view enough height to fully intersect with each extruded front shape, as shown in Figure 33.

Step 3 Select all the graphics, right-click on the selection, and choose Intersect Faces with Selection in the pop-up menu. Once you've deleted the waste between the slats, you will be able to see the "intersect edges" on each back slat extruded shape (Figure 34).

Step 4 Use the Eraser Tool to clean up the remaining waste, yielding the final back slats, as shown in Figure 35.

How to Make a Rule Joint

Drop-leaf tables, like the breakfast table shown in Figure 36, traditionally use a rule joint and specially designed hinges to create a strong rotating connection between the leaves and the main tabletop. Figure 37 is a close-up view of the joint, with the leaf dropped.

Here are the basics for making a rule joint. The process is slightly more difficult if the top has a thumbnail molded edge because you have to do some intersecting to clean up the molded areas. The top of the table shown here is ½ in. thick, but the design process is the same if you make the joint in thicker material. The radius of the roundover increases as the thickness increases.

There is a direct relationship between the center of the roundover arc and the center of the hinge pin. Figure 38 shows a

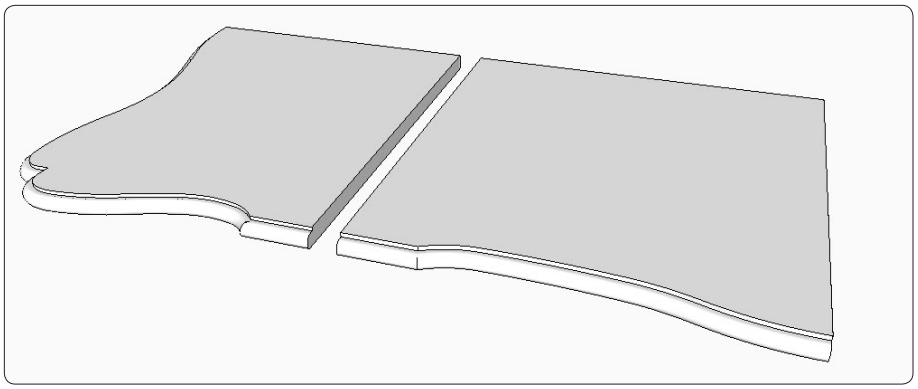


Figure 39. *Begin designing the rule joint on edges that will be the center of the tabletop and leaf.*

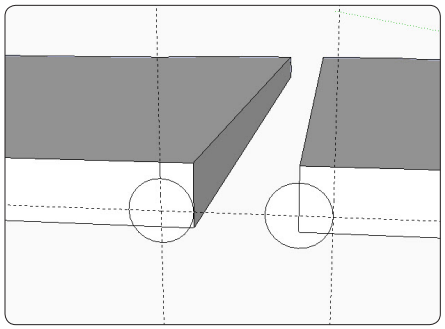


Figure 40. *Begin the joint by placing guidelines and circles that will determine the roundover and matching cove of the joint.*

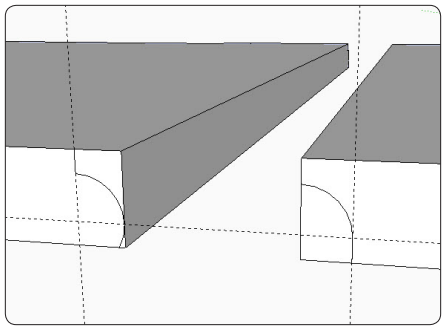


Figure 41. *Place short vertical lines over the guidelines to define the shape of each half of the joint.*

cross-section view of the tabletop through the hinge. Note how the hinge-pin center and the center of the roundover arc coincide. In practice, the hinge location may shift to the left by 1/32 in. to decrease the chance of having the leaf bind as it's raised or lowered. It's best to have the hinges you'll use on hand before you begin drawing the joint, so you can take exact measurements for the model.

Step 1 Begin with segments of the top and leaf components. Because the tabletop is symmetrical, you need only half of each component. This allows you to create the rule joint on the flat edge that will become the centerline of the top (Figure 39). Adding the rule joint will necessarily decrease the length of the top and leaf because they overlap in the joint area. So be sure to give those components extra length at the outset to achieve the desired tabletop size.

Step 2 Use the Orbit Tool to move around to the flat edge of the top and leaf. Place a guide line up from the bottom edge a distance equal to the height of the hinge-pin centerline (about 1/8 in). Determine the radius of the roundover by subtracting the depth of the quirk (which must match the thumbnail molding) and the height of the hinge pin from the overall thickness of the top. In this case, both the quirk and the hinge pin are 1/8 in., leaving a roundover radius of 1/4 in. Place vertical guide lines at a distance equal to the radius from the outer edge of the top and leaf. Draw identical circles, as shown in Figure 40.

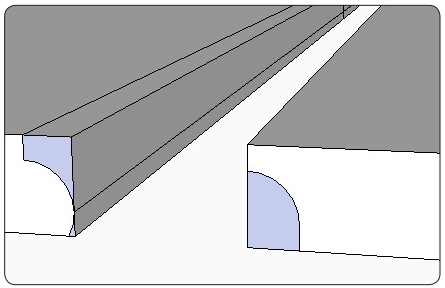


Figure 42. *Use the Push/Pull Tool to push the roundover and cove shapes beyond the front edge of the top and leaf.*

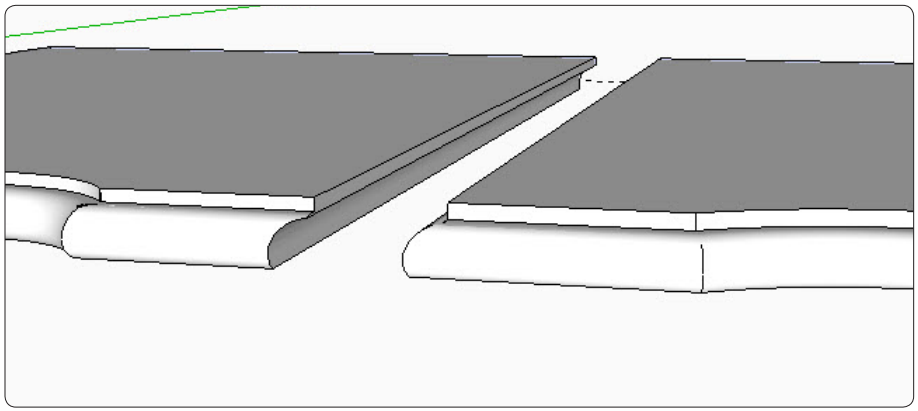


Figure 43. *The rule joint, seen from the front edge of the tabletop.*

Step 3 Remove the circles' waste portions, leaving only the roundover and cove shapes on the face of the top and leaf. Place short vertical tangent lines from the arcs to the edges of the leaf and top, as shown in Figure 41.

Step 4 Select the Push/Pull Tool and press the Ctrl key (Option on the Mac). Push out the roundover shapes beyond the front edges of the top and leaf, as shown in Figure 42.

Step 5 Orbit Tool around to the molded front edge of the top and leaf. Select all the graphics in the top, right-click on the selection, and choose Intersect Faces with Selection from the pop-up menu. Clean up the waste with the Eraser Tool. Do an identical Intersect Faces with Selection process on the leaf. The result will look like the joint shown in Figure 43.

To finish the top and leaf, copy the components, execute a Flip Along command, and join the halves.

Wooden Hinge for a Table Leaf Support

This exercise shows the steps required to make a wooden hinge that would be typical on table designs with fold-down leaves, such as the breakfast table shown here. Figure 44 shows the hinged leaf supports, with the top hidden. The hinge consists of two pieces, one half of which is glued to the table's fixed rail. Figure 45 shows the fixed and rotating pieces of the hinge. I'll show the steps involved in making the hinge; as with other projects in this chapter, exact dimensions will vary, depending on the size of the table you choose to design.

Step 1 Begin by roughing in the fixed half of the hinge within the context of the assembled table. Create the upper face of this hinge half, which has a corner made from a ¾-in.-diameter circle. Place a guide point at the center of the circle. The hinge center falls at the midpoint between the legs (Figure 46).

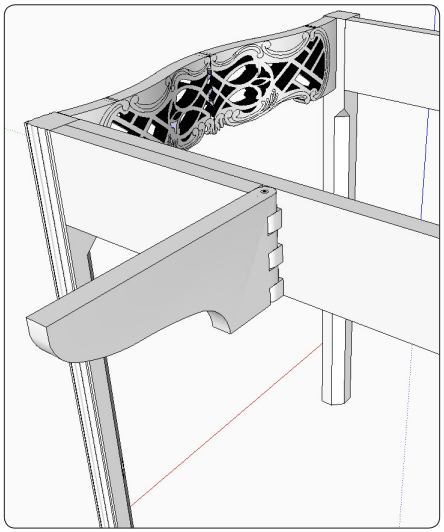


Figure 44. *A breakfast table with a fold-down leaf that's supported with a wooden-hinge.*

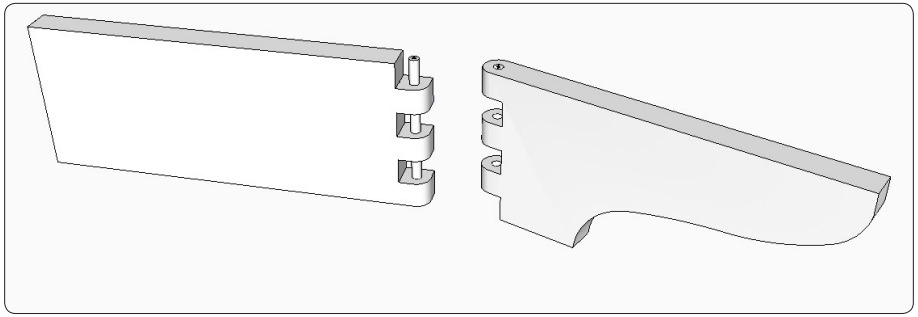


Figure 45. *The fixed and rotating parts of the hinge, with the pin that holds them together.*

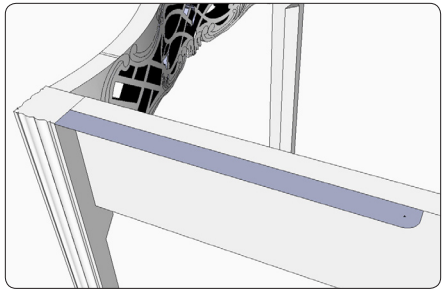


Figure 46. *Begin by roughing in the fixed half of the hinge in position on the table.*

Step 2 Make the hinge the desired height, make it a component, and begin laying out the knuckles. Draw a vertical line on the face and divide it into six segments—this is the same technique used to lay out dovetails shown in Chapter 8.

Place horizontal guidelines at the division points on the line. To create the gaps in the hinge, use evenly spaced cutting planes. These are small rectangles drawn on the red–green axis and moved into position on the division points; in effect, the planes become faces of the hinge knuckles. The size of the cutting planes isn't important, as long as they are larger than the end of the hinge. Draw a small circle on the top of the hinge, with the guide point as its center. Use the Push/Pull Tool to push the circle through all the knuckles, creating the hinge pin. It won't be a permanent part of the model. Instead, use the pin to make the holes in the knuckles. Select all the graphics, right-click, and execute an Intersect Faces with Selection command. Remove the waste between the knuckles, leaving the holes. Figure 47 shows the pin before executing the Intersect command.

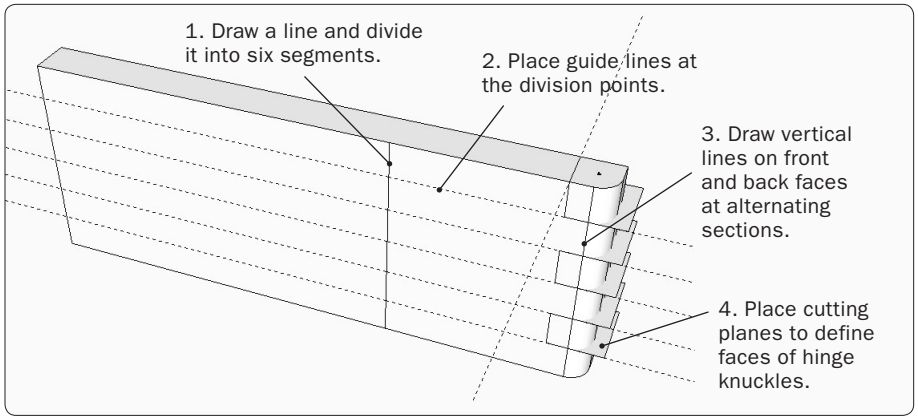


Figure 47. *Create the fixed hinge leaf. Place guide lines to lay out the knuckles, and insert cutting planes where the ends of the knuckles fall. Select all the graphics, and choose Intersect Selected.*

Step 3 Remove the waste, leaving a leaf with three knuckles, as shown in Figure 48.

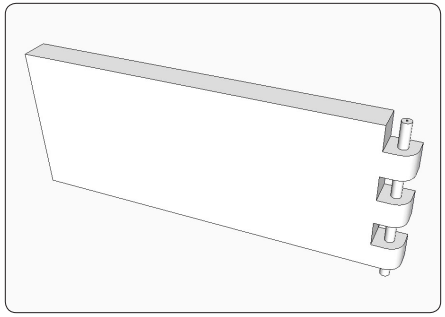


Figure 48. *The fixed half of the hinge, with the hinge pin in place.*

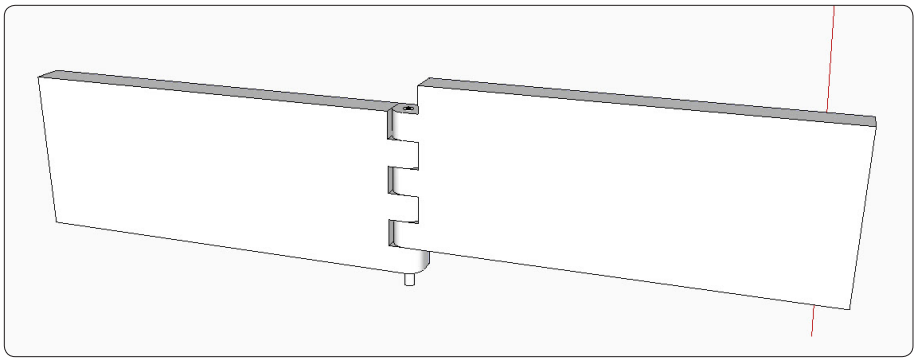


Figure 49. *Copy the fixed half, then flip it and offset it to create the movable hinge half.*

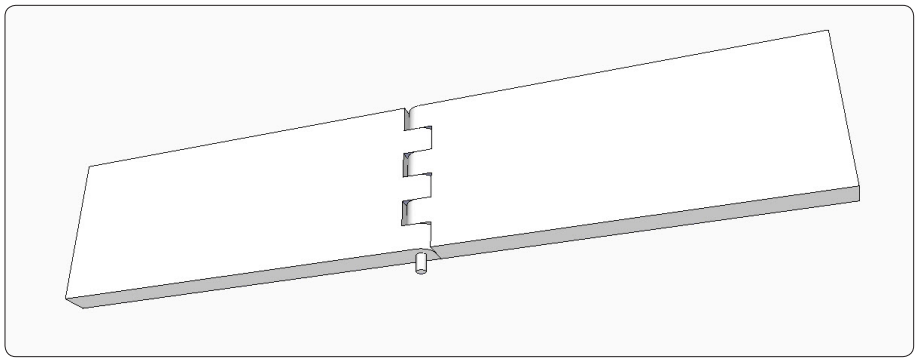


Figure 50. *Use the Push/Pull Tool to shift the top and bottom faces of the movable hinge leaf.*

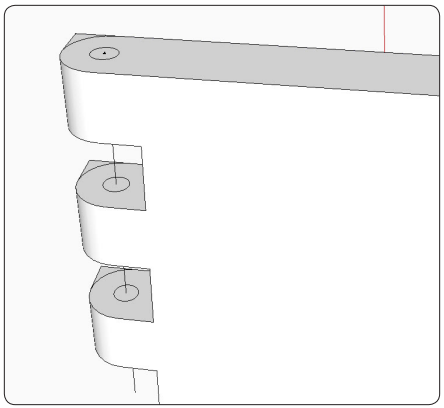


Figure 51. *Round the knuckles of the movable hinge leaf.*

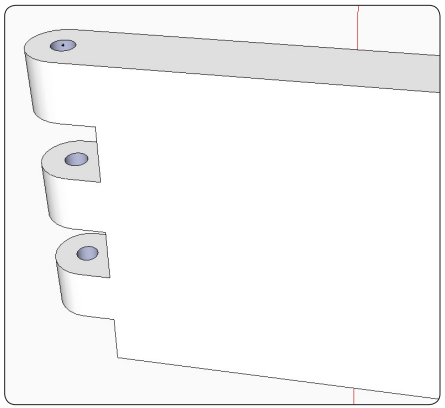


Figure 52. *The completed knuckles on the movable leaf.*

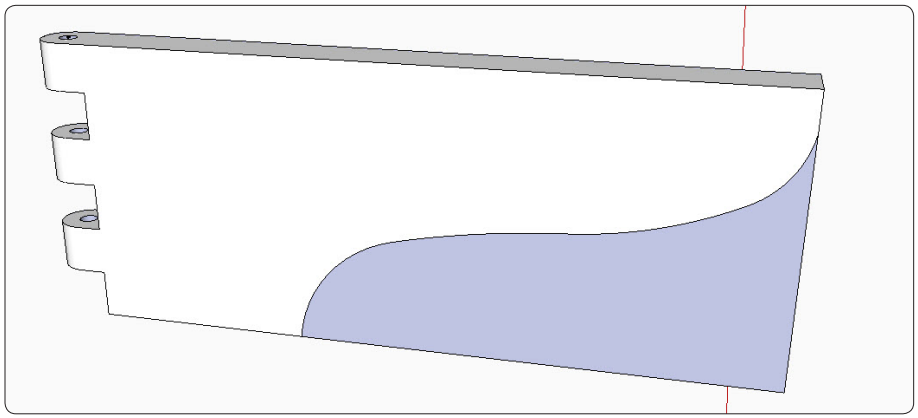


Figure 53. *Create the ogee-shaped cutout on the movable half of the hinge.*

Step 4 Use the fixed hinge half to make the movable half. Copy the fixed half, move it to the right, execute a Flip Along command, and move the copy so that it's offset from the fixed half by the width of one knuckle (Figure 49). Make the copy a unique component.

Step 5 Use the Push/Pull Tool to push down the top face of the movable half so that it lines up with the top face of the fixed half. Draw a line across the bottom face, as shown in Figure 50, and use the Push/Pull Tool to pull the lower face even with the corresponding face of the fixed half.

Step 6 Round over the outside corners of the knuckles on the movable portion of the hinge. Use the Circle Tool to create the corner arcs, as shown in Figure 51. Then use the Push/Pull Tool to remove the corners on the knuckles, leaving their ends, as shown in Figure 52.

Step 7 Use the Arc and Push/Pull Tools to create the cutout shape on the movable hinge leaf, as shown in Figure 53. Connect the two halves of the hinge and place it into the table assembly. Copy and use the Rotate Tool to place the duplicate hinge on the other side of the table. Use the Rotate Tool to swing the movable portion of the hinge part way out, as shown in Figure 54.

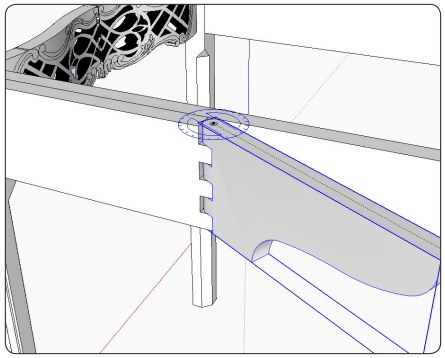


Figure 54. *The completed hinges, in position.*

How to Make a Window Sash

Glass doors with molded mullions and muntins are challenging woodworking projects. (Strictly speaking, mullions are the vertical dividers; muntins, the horizontal ones. For simplicity's sake, I'll call all the dividers muntins.) Working through the detail design in SketchUp clears up any uncertainty in the construction of these complex pieces. I will show how to use cutting planes and the Intersect function to create the mitered joints at the ends of the stiles and rails, where a muntin joins a stile, and where muntins cross. The techniques are similar for breakfront doors, although they may have angled muntins. Figure 55 shows a fully assembled sash, and Figure 56 gives an exploded view.

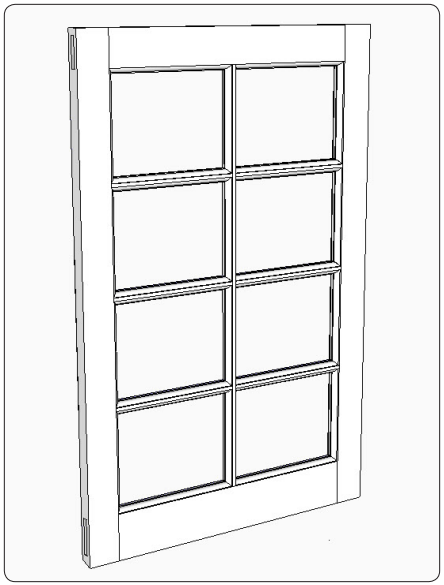


Figure 55. *A traditional window sash, with mullions and muntins holding the panes of glass.*

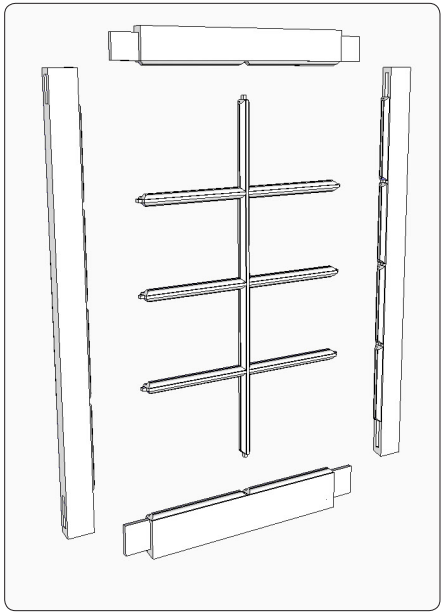


Figure 56. *An exploded view of the sash.*

Step 1 Begin by drawing the muntin cross-section shape or importing an image of the cross section, like the one shown in Figure 57.

Step 2 Draw the end face of the top rail and connect half of the muntin shape to it, as shown in Figure 58. Use the Push/Pull Tool to extrude the top rail, producing the shape shown in Figure 59.

Step 3 Draw the tenon on the end; the size depends on the window or door you're making (Figure 60). Then copy it, execute a Flip Along command, and attach the copy to the opposite end of the rail.

Step 4 To make the miter cut in the molded lower edge, draw a cutting plane set at 45 degrees, as shown in Figure 61. It's similar to the technique used in Chapter 12 to miter the thumbnail profile on the doors for the Colonial cupboard. Copy the cutting plane and move the copy down and away from the rail; you'll use this copy in the next step.

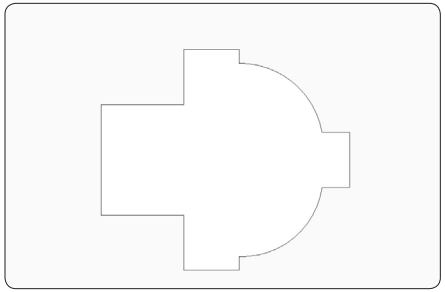


Figure 57. *The cross-section shape of the muntin.*

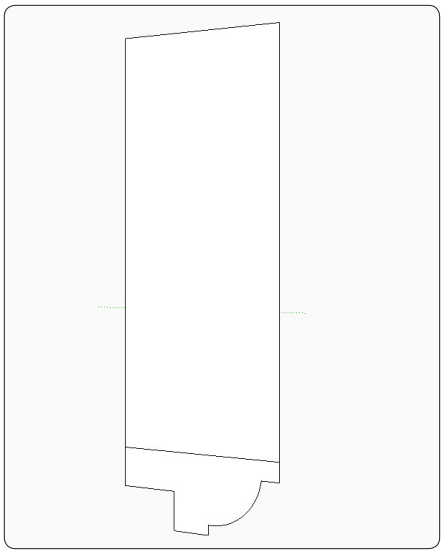


Figure 58. *The end face of the top rail, with half the muntin shape attached.*

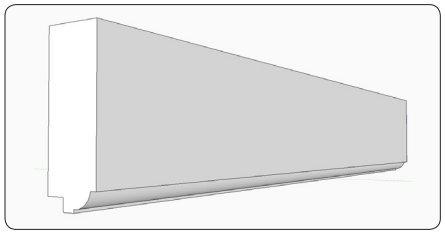


Figure 59. *The top rail extruded to length and with its molded edge.*

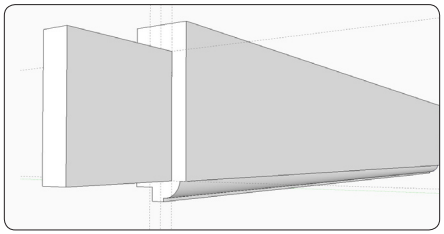


Figure 60. *Create a tenon on one end and copy it to the opposite end.*

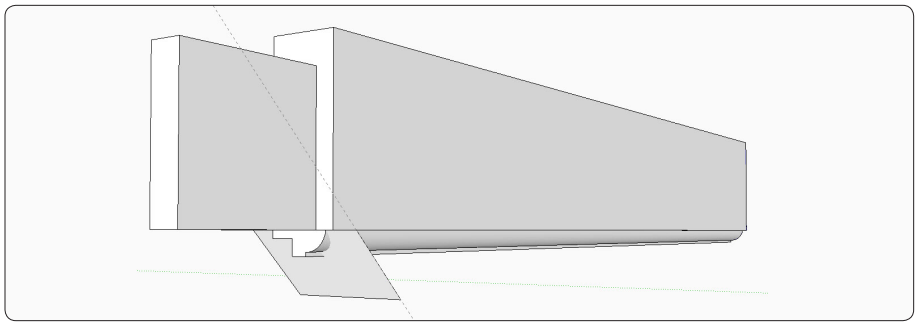


Figure 61. *Draw a cutting plane at a 45-degree angle to miter the molded edge.*

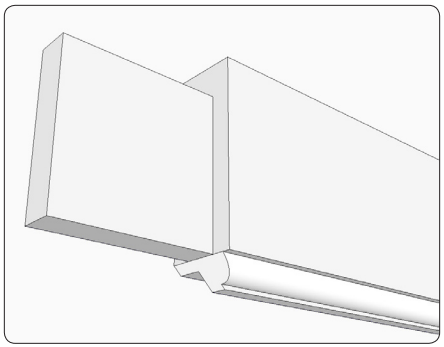


Figure 62. *The finished miter joint.*

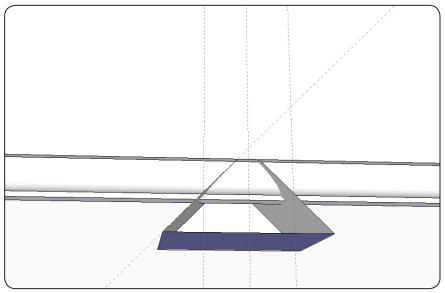


Figure 63. *Draw cutting planes to remove material for a socket to hold the vertical muntin.*

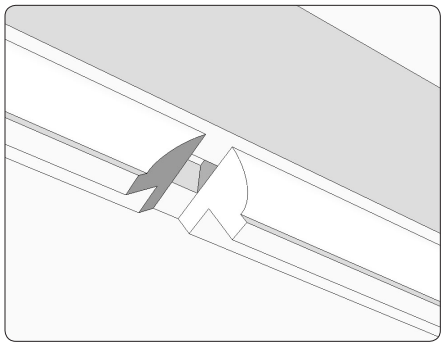


Figure 64. *The completed socket.*

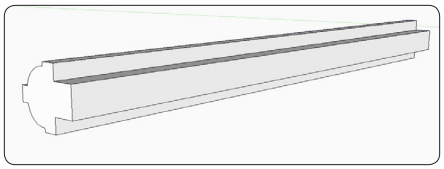


Figure 65. *Use the cross-section shape to make a muntin.*

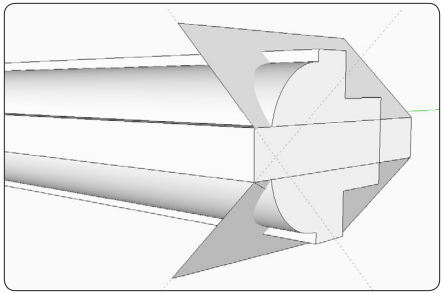


Figure 66. *Place cutting planes to miter the end of the muntin.*

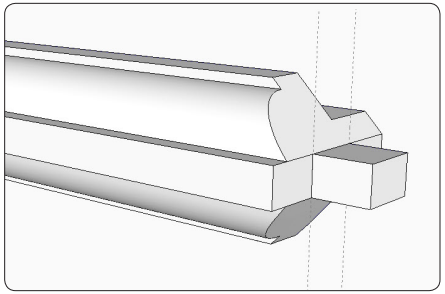


Figure 67. *Draw a small tenon on the end of the muntin.*

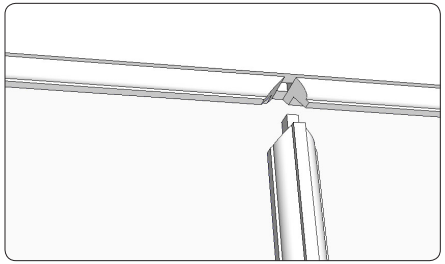


Figure 68. *Insert the muntin into the top rail. The mitered sections should be a good, tight fit.*

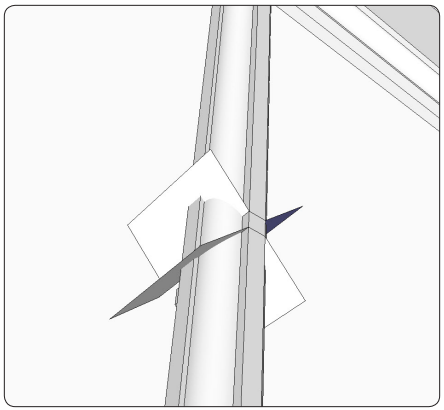


Figure 69. *Place more cutting planes to miter the vertical muntin where it crosses with a horizontal one.*

When you have placed the original cutting plane, select all the graphics, right-click, and choose Intersect Faces with Selection. Remove the waste, leaving the mitered edge shown in Figure 62.

Step 5 Miter the molded edge of the rail and create a socket where the vertical muntin connects to the center of the top rail.

To miter the edge, begin by drawing a guide line at the midpoint of the rail and parallel guide lines ⅛ in. on each side of the midpoint guide line. The ¼-in. space corresponds to the width of the central rib on the top face of the muntin. Connect the copy of the cutting plane where one of the parallel guidelines intersects the lower edge of the rail. Copy the cutting plane, execute a Flip Along command, and place it on the opposite parallel guideline (Figure 63). Select all the graphics and execute an Intersect Faces with Selection command. Clean up the waste.

The socket for the end of the muntin is centered between the mitered moldings on the rail. In this case, the tenon is ¼ in. by ⅜ in. and ⅜ in. deep. Draw the face of the socket, then use the Push/Pull Tool to give it the proper depth. You should be left with a mitered cutout like the one shown in Figure 64.

Step 6 Use the Push/Pull Tool to extrude the cross-section shape of the muntin (Figure 65). Draw a pair of cutting planes at 45-degree angles on one end, as shown in Figure 66. Select all the graphics in the muntin and cutting planes, right-click, and choose Intersect Faces with Selection from the pop-up menu. Remove the waste.

Step 7 Place guidelines to make a small tenon on the end of the muntin. Its dimensions are the same as those of the socket created in Step 5. Draw the boundary of the tenon with the Line Tool and pull it to length with the Push/Pull Tool (Figure 67).

Step 8 Use the Move/Copy Tool to latch onto a corner of the muntin that corresponds with a matching corner in the top rail socket. Insert the muntin into the top rail socket, and click when the matching corners connect (Figure 68).

Step 9 Determine where the muntins will cross and place guidelines to aid in drawing cutting planes. Draw a pair of cutting planes (Figure 69) to miter the muntin again. The space between the cutting planes equals the width of the central rib in the muntin. As before, select the graphics and execute an Intersect Faces with Selection command. Once you have

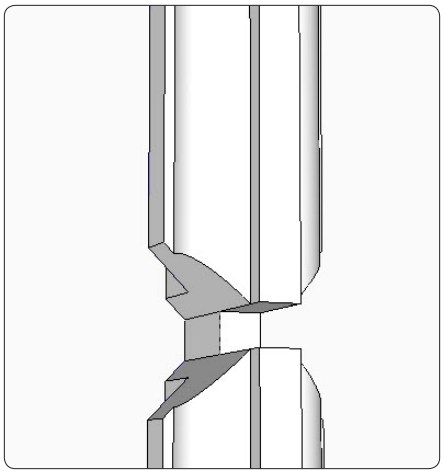


Figure 70. *Push down the center part of the muntin to make a half-lap joint.*

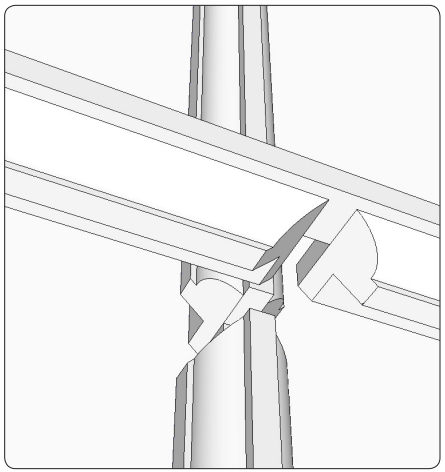


Figure 71. *Crossing muntins, mitered on the ends and connected with a half-lap joint.*

removed all the waste, use the Push/Pull Tool to push the central rib down half the thickness of the muntin to create the half-lap joint shown in Figure 70.

Step 10 Make another muntin and repeat the procedures in Step 9 to miter it and make the half-lap joint. This time, however, push in the back face of the muntin to make the mating half of the lap joint (Figure 71).

Repeat these steps as needed to finish the ends of the stiles and rails, miter them for muntins, and intersect the horizontal and vertical muntins.

How to Rough In the Back Leg of a Maloof-Style Rocker

So far I've used only classic period furniture for my examples. Here, I'll show you how SketchUp can create part of a very contemporary piece: a Maloof-style rocking chair, as shown in Figure 72. Articles in *Fine Woodworking* magazine issues #25 and #42 contained useful front and side views and details about the joinery. I scanned and imported the illustrations into SketchUp.

Step 1 After importing the *Fine Woodworking* illustration, align it with the red and blue axes and scale it so that the dimensions in the image are equal to those of the actual full-size piece. Trace over the shapes of the seat, front and back legs, and arm, as shown in Figure 73. Do trace-overs of the same pieces in the front view, as shown in Figure 74.

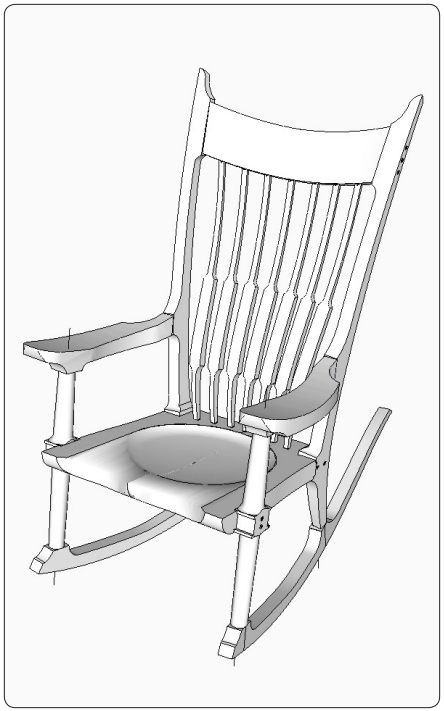


Figure 72. *The Maloof rocker.*

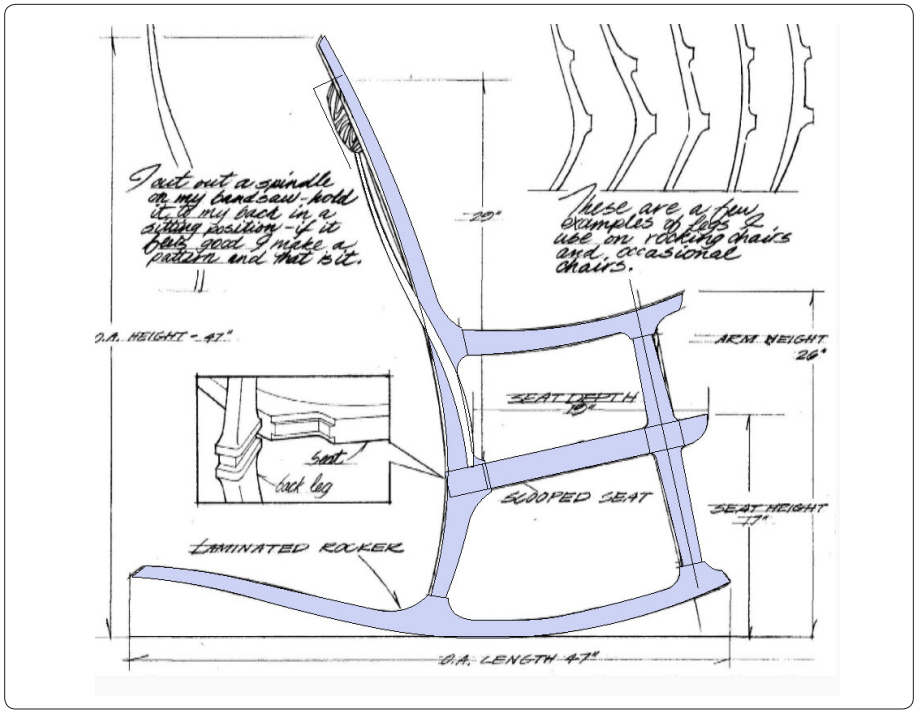


Figure 73. *Trace over the shapes from the imported image.*

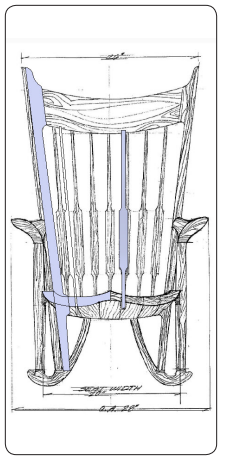


Figure 74. *Add trace-overs from the front view.*

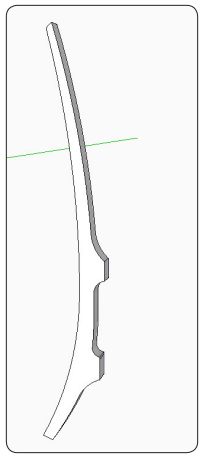


Figure 75. *Give the side view of the leg its thickness.*

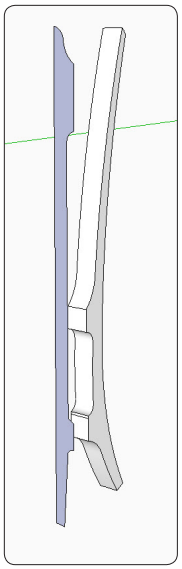


Figure 76. *Place the front view of the leg directly in front of the side view.*

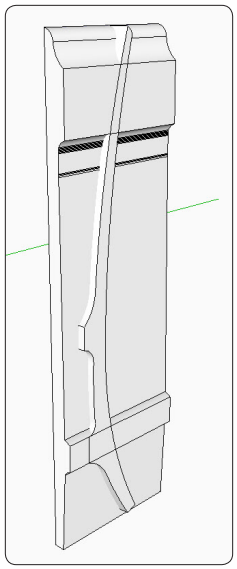


Figure 77. *Push the front view completely through the side view, then execute an Intersect command.*

Step 2 Use the Push/Pull Tool to give the side view of the leg its thickness, as shown in Figure 75.

Step 3 Line up the front shape directly in front of the side view leg blank, as shown in Figure 76.

Step 4 Use the Push/Pull Tool to push the front shape through the leg blank, as shown in Figure 77. Select all the graphics, right-click, and choose Intersect Faces with Selection from the pop-up menu. Remove the waste and lay out the leg joints. Figure 78 shows the shaped leg. You can make the other parts of the rocker in similar fashion.

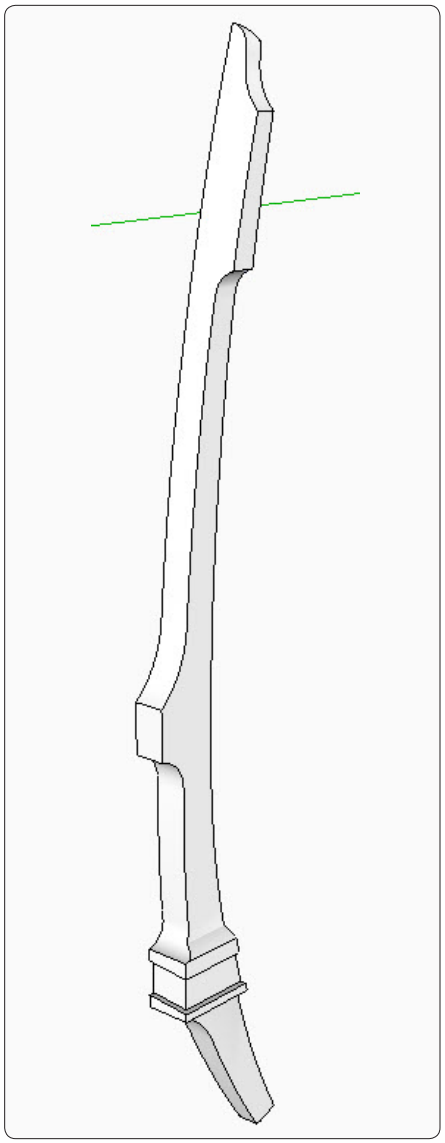


Figure 78. *The completed leg. It's not rounded and the joints aren't yet faired, but that's work that can easily be done in the shop. The SketchUp model gives me the important information about the leg's size and shape.*

Sculpting a Windsor Seat

One step left undone in the discussion of the Windsor chair in Chapter 12 was the sculpting of the seat. Here's one way to do it, using brute force capabilities inherent in SketchUp rather than a specialized plug-in.

The results are crude and perhaps insufficient, but doable without too much effort. The sculpting process applies to other types of chairs and other complex shaped components.

Figure 79 shows the chair with its sculpted seat. Figure 80 shows a half-seat blank before contouring. It's the same seat used in Chapter 12, which you can also use here to try your hand at sculpting.

Step 1 Create a small, shallow arc shape for the gutter on the centerline edge of the seat, between the parallel curved lines in front of the spindle sockets. You can use either of those curved lines as the path for the Follow Me Tool; just extend the line you want beyond the seat's far edge, as shown in Figure 81. Execute a Follow Me command to shape the gutter, which will extend beyond the seat's edge. Execute an Intersect Faces with Selection command at that area to clean up the waste and the extension. (Scale up the seat by a factor of 10 for best results.) Figure 82 shows the finished gutter.

Step 2 Cut back the underside of the front and side edges of the seat. Chapter 12 explains how to place lines to indicate how much the underside should

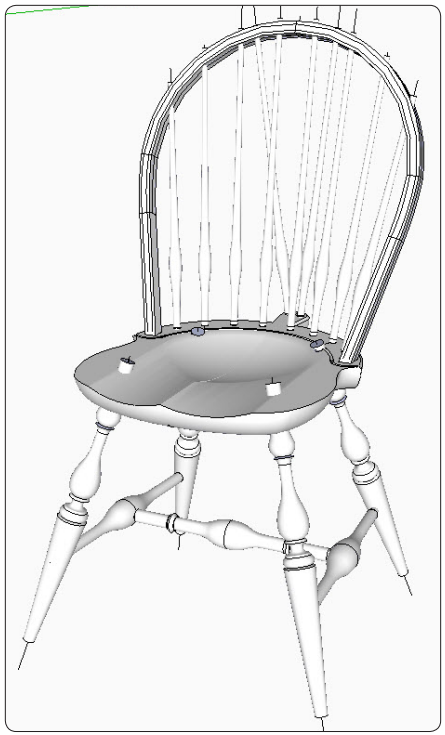


Figure 79. *A bow-back Windsor chair with sculpted seat.*

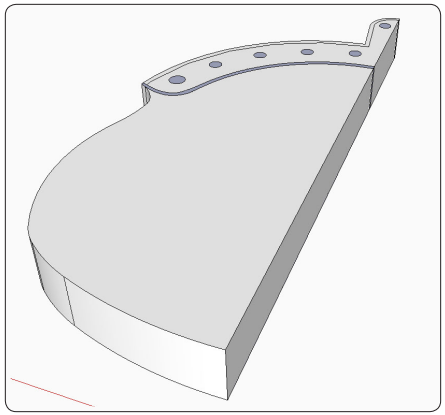


Figure 80. *The half-seat before any of the sculpted details are added.*

be cut back. Use the Arc Tool to place an arc on the flat centerline edge of the seat blank, as shown in Figure 83. The top front edge of the blank seat, lengthened beyond the seat's edge, serves as the path for the Follow Me Tool. Choose the Follow Me Tool and click on the arc, producing the shape shown in Figure 84. You'll need to execute an Intersect command to clean up the model where the shape extends beyond the seat's edge.

Step 3 Use the Orbit Tool to move around to the back of the seat, then draw another arc representing the undercut for the rear of the seat. The seat's top back edge serves as the path for the Follow Me Tool in this step. Repeat the procedure in Step 2 to finish curving the edge of the seat (Figure 85). Use the Arc Tool to place a small cove shape on the seat's top back edge, as shown in Figure 85. Follow the procedures in Step 2 to make the cove shape.

Step 4 Begin scooping out the seat's top surface by making a semicircular hollow. Place a guide line on the seat's centerline edge to indicate how deep the scooping will go. Place a vertical guide line to show the center of the path for the Follow Me Tool. Draw a semicircular arc on the seat's top edge for the path. Finally, draw an arc on the centerline edge to define the shape of the hollow. The completed layout is shown in Figure 86, and the scooped-out shape is shown in Figure 87.

Step 5 Draw an arc shape at the front of the seat, as shown in Figure 88. Use the Push/Pull Tool to push the shape toward the back of the seat, into the center scooped area. Execute an Intersect Faces with Selected command. Remove the waste to produce the shape on the front of the seat, as shown in Figure 89.

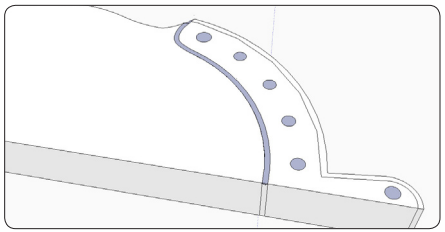


Figure 81. *Use the Follow Me Tool to make the small, shallow gutter at the rear of the seat.*

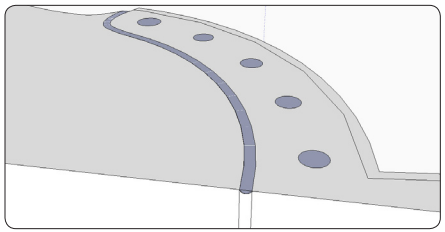


Figure 82. *The completed gutter.*

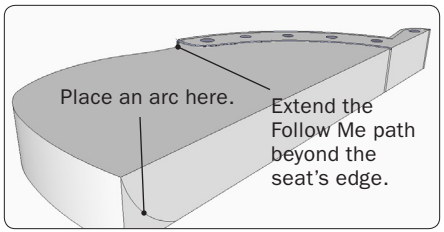


Figure 83. *Place an arc to define the shape of the seat edge, then use the Follow Me Tool to carry that shape along the curved side of the seat.*

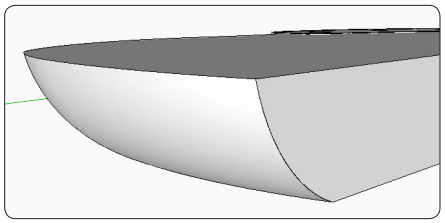


Figure 84. *The front edge of the seat after shaping.*

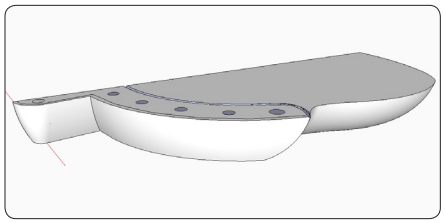


Figure 85. *With the rear shaped, the seat's edge is fully undercut. Add a cove around the rear edge.*

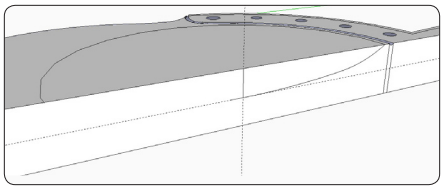


Figure 86. *Place guide lines to mark the depth of the scooping on the seat, an arc on the edge to define the shape of the scoop, and a semicircular arc as a path for the Follow Me Tool to define the scoop.*

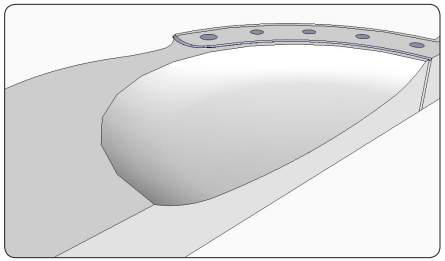


Figure 87. *The scooped-out shape.*

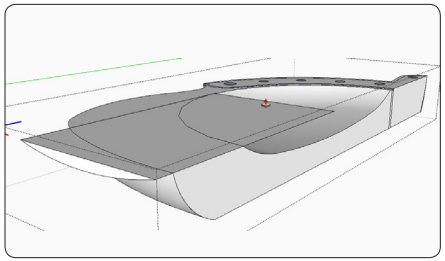


Figure 88. *Draw an arc at the front of the seat to define the second scooped-out shape.*

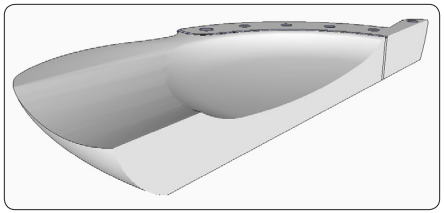


Figure 89. *Use the Push/Pull Tool followed by an Intersect command to produce the second scooped-out shape.*

Step 6 Use the Eraser Tool after pressing the Shift key to hide the top edge of the seat centerline. That way, when you connect the two halves, there won't be a hard line at the centerline. Use the Soften/Smooth Edges function to remove hard lines on the surface. Then copy and

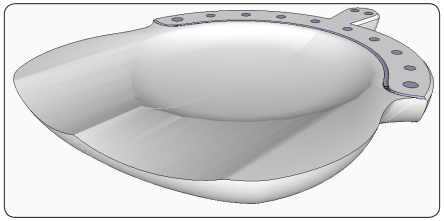


Figure 90. *The completed, sculpted seat.*

flip the seat half to produce a complete seat, as shown in Figure 90.

How to Make a Carving

I'll use the Williamsburg tea table shown in Figure 91 to illustrate two ways to apply carvings to a piece of furniture. The images used to replicate the table appeared in *Fine Woodworking* magazine #43. The article included a detailed illustration of the carvings for the skirt, knee, and corner shell (Figure 92). I scanned and imported the artwork so I could trace over it in SketchUp.

Step 1 Since the skirt carving is symmetrical, you need to trace over only half of the scanned image. Work slowly and patiently. All the arced lines on the face cause some difficulty with SketchUp, which wants to fill in the faces. Use temporary lines to connect between existing lines to close partial faces. Continue until the entire half shape is filled in with a face (Figure 93).

Step 2 Copy the half shape, execute a Flip Along command, and connect it to the original to make the entire carving. Then use the Push/Pull Tool to give the carving thickness, as shown in Figure 94. The amount of thickness isn't critical, because any excess will be removed after you execute an Intersect command.

Step 3 Seen in profile, the carving is shaped to be fat at the bottom and thin toward the top. To give your design that profile, make an arc shape like the one shown in Figure 95 to serve as a cutting plane.

Step 4 Use the Push/Pull Tool to push the cutting plane through the carving

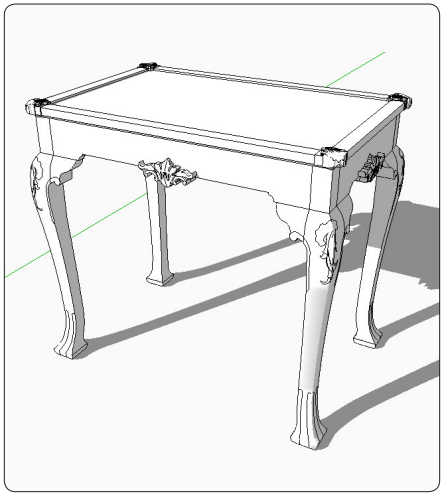


Figure 91. *Carvings are a distinctive feature of this tea table.*

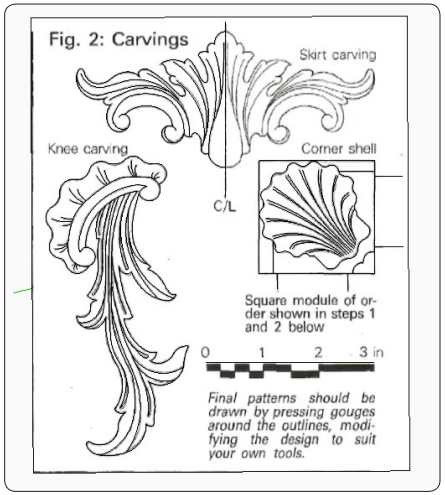


Figure 92. *The illustration that forms the basis for the carvings in SketchUp.*

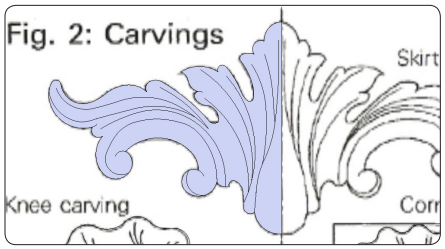


Figure 93. *Trace half the carving, including the outline and the arcs detailing the carved shapes.*

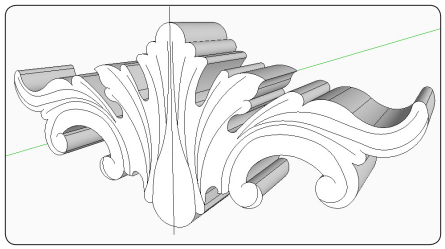


Figure 94. *Copy and flip the tracing to create the full carving shape, then give it thickness.*

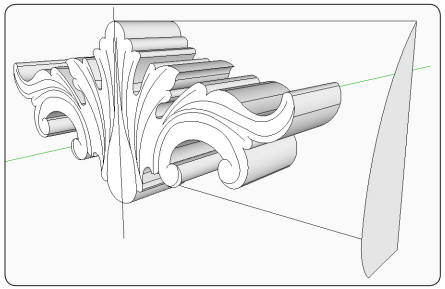


Figure 95. *Make a shape to intersect with the carving, to give the carving its proper profile.*

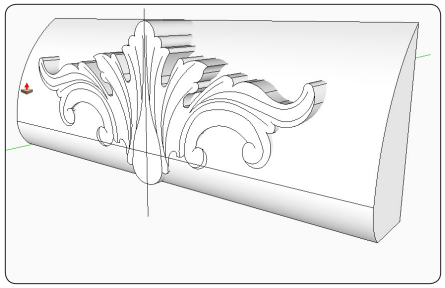


Figure 96. *Push the cutting plane through the carving.*

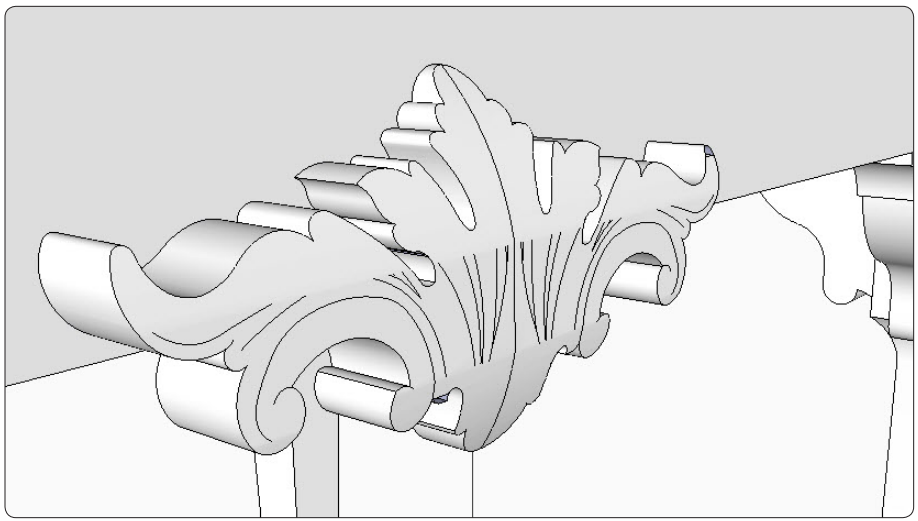


Figure 97. *The completed carving applied to the tea table skirt.*

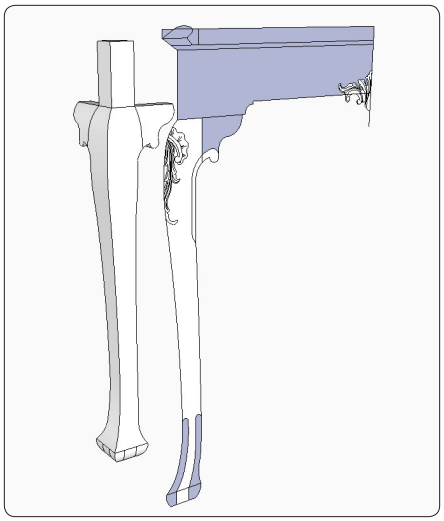


Figure 98. *After tracing over the scanned image of the leg carving, move an unadorned cabriole-leg component directly behind the trace over.*

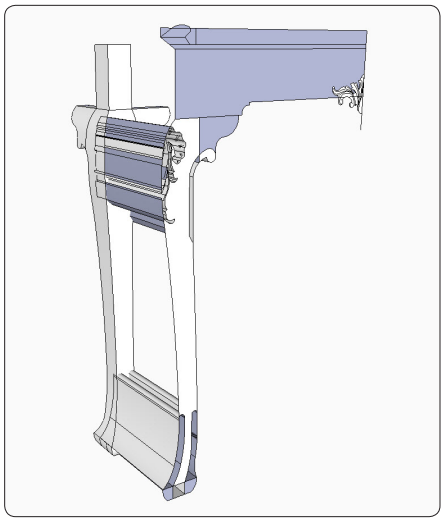


Figure 99. *Push the traced-over carving shape through the cabriole leg.*

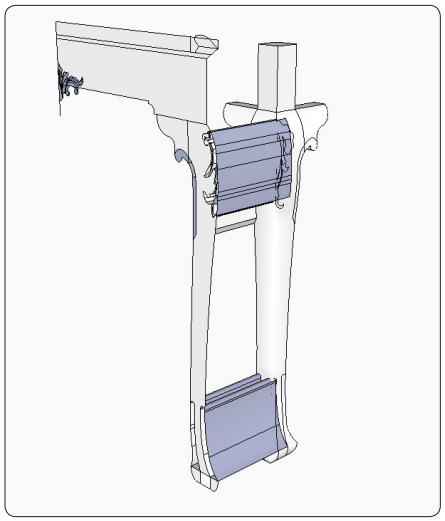


Figure 100. *Brand the other face of the leg with the rest of the carving.*

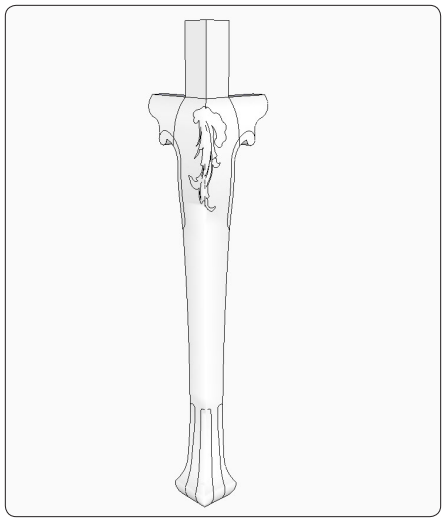


Figure 101. *The completed leg, with the carvings branded on the surface.*

(Figure 96). Select all the graphics, right-click, and choose Intersect Faces with Selection from the pop-up menu. Remove the waste. Place the finished carving on the skirt, as shown in Figure 97.

Step 5 I use a technique I term *branding* for the leg carvings. In this case, I don't try to create a 3D carving on the leg; instead, I imprint the shape on the leg's surface. As before, I begin by tracing over the scanned image of the leg carvings, then position the 3D cabriole-leg component directly behind the traced-over face (Figure 98).

Step 6 Use the Push/Pull Tool to push the carving shapes through the surface of the cabriole leg, as shown in Figure 99. Select all the graphics, and execute an Intersect Faces with Selection command. Clean up the waste, leaving only the impression, or brand, of the carving on the leg surface. Rotate the tracing and leg so you can brand the other face of the leg with the rest of the carving (Figure 100). Figure 101 shows the completed leg.

How to Create a Hardware Hinge

Hardware is a critical part of a furniture model. It impacts the design and is important for the visual reality of the piece. I typically rough out hinges, pulls, and the like, showing overall size but few details. However, it's sometimes desirable to fully model a hinge, like the one shown in Figure 102. It's a Brusso stop hinge that might be used on, say, a box lid. Here's how to reproduce it.

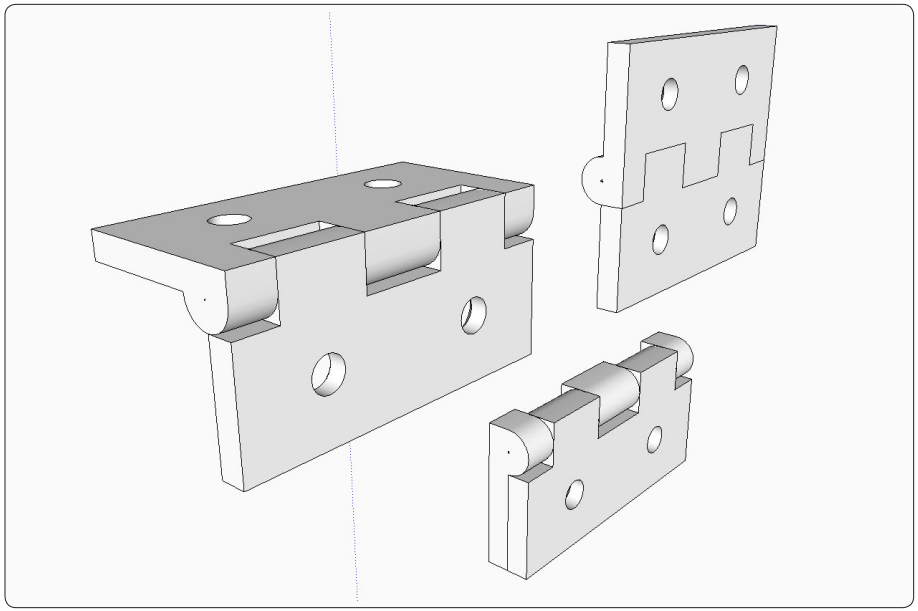


Figure 102. *A Brusso stop hinge.*

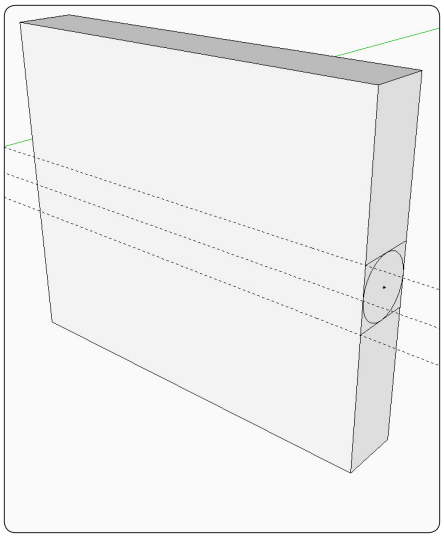


Figure 103. *Draw a face the size of the fully opened hinge, make it as thick as two leaves, and draw the diameter of the knuckle.*

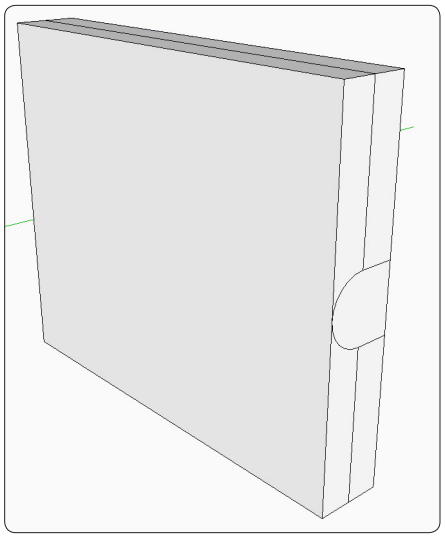


Figure 104. *Bisect the plate and clean up the knuckle.*

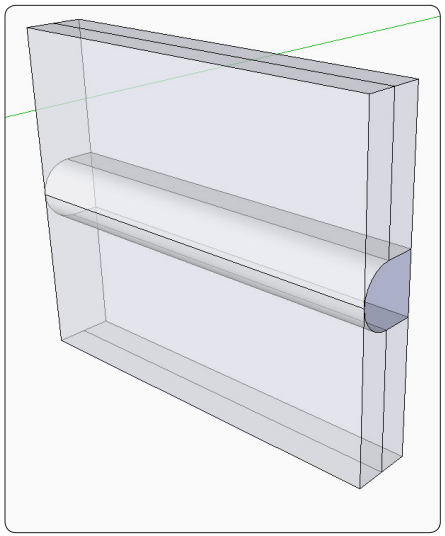


Figure 105. *Push the knuckle all the way through the leaf.*

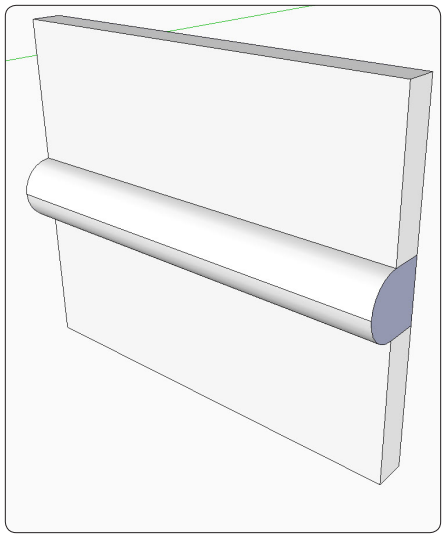


Figure 106. *Remove half the thickness of the hinge plate.*

For this exercise, I used a hinge measuring 1¼ in. by 1$\frac{1}{32}$ in. by $\frac{3}{16}$ in. overall. If you want to model a different hinge, have an actual one on hand so you can check dimensions.

Step 1 Draw a face the same size as the fully opened hinge. Give the hinge its thickness (twice the thickness of a single leaf). Place guide lines to locate the center of rotation and knuckle. Then draw lines and a circle to outline the knuckle (Figure 103).

Step 2 Draw lines around the midpoint of the edges to bisect the plate. Use the Eraser Tool to clean up the waste lines for the knuckle shape. You should have a sketch like the one shown in Figure 104.

Step 3 Select the Push/Pull Tool and tap the Ctrl key (Option on the Mac). Push the knuckle shape all the way through the plate to the other end. Figure 105 is an x-ray view showing the knuckle pushed through.

Step 4 Use the Eraser Tool to delete half the thickness of the plate, as shown in Figure 106.

Step 5 Place guide lines to divide the knuckle. In this case, it's divided into four segments, with a half segment at each end. Draw cutting planes and place them at the dividing points (Figure 107).

Step 6 Draw a left-to-right selection box around all the hinge parts. Right-click on the selection, and choose Intersect Faces

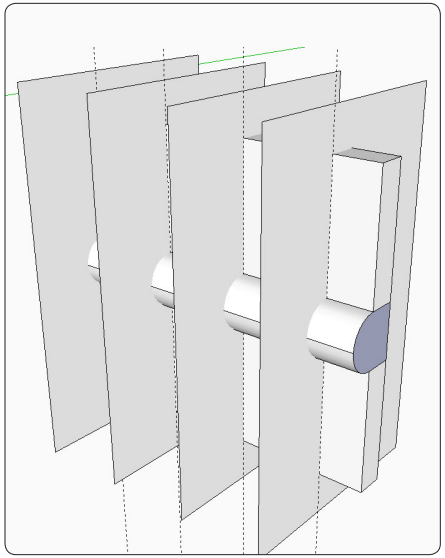


Figure 107. *Divide the knuckle into equal segments, then draw and place cutting planes at the divisions.*

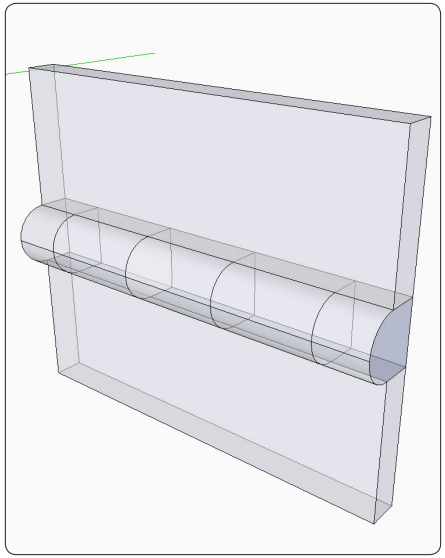


Figure 108. *Execute an Intersect Faces with Selection command, then remove waste to leave an open hinge with a divided knuckle.*

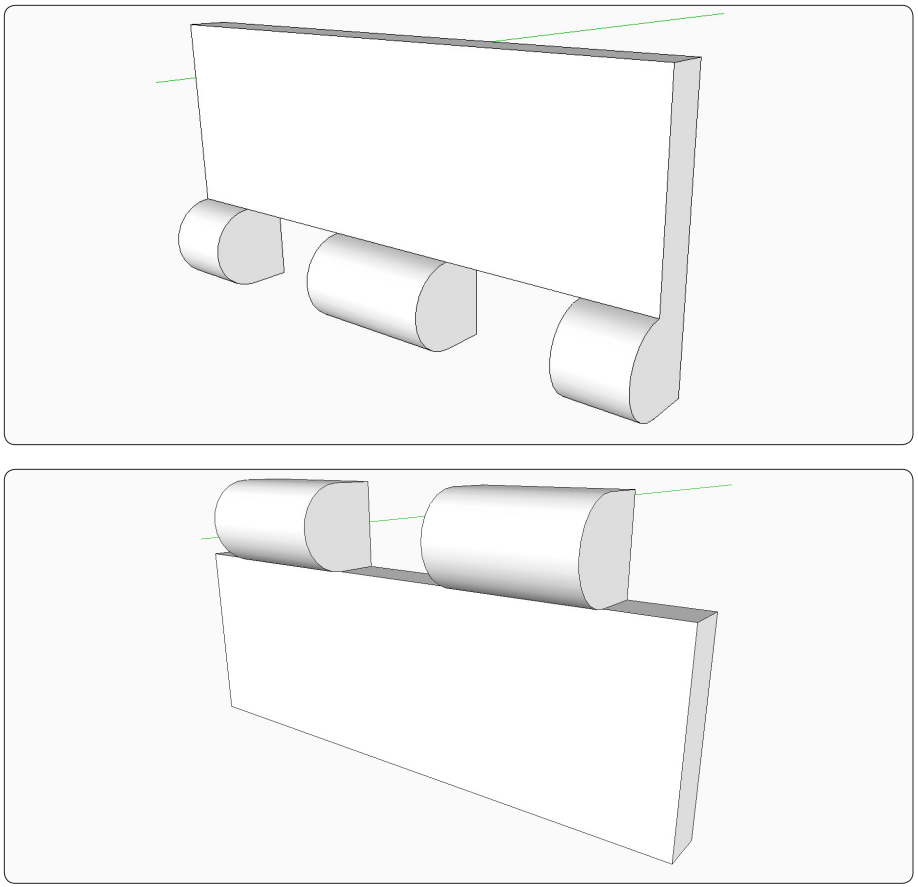


Figure 109. *Copy the hinge twice. On one copy, remove the lower half; on the other, the upper half.*

with Selection from the pop-up menu. Use the Eraser Tool to remove the waste. Now, as you can see from Figure 108, the knuckle is divided into segments.

Step 7 Make two copies of the hinge plate with divided knuckle. Make each a unique component. On one copy, use the Eraser Tool to remove the lower half of the hinge. On the second copy, remove the upper half (Figure 109).

Step 8 Make the screw holes. Place guide lines to find the centers of the holes. Use the Circle Tool to place an 1/8-in.-diameter circle at each center point. Use the Push/Pull Tool to push the circle through for a hole. Place a 3/16-in.-diameter circle over the center point, so it's concentric with the hole. Select the inner circle, use the Move/Copy Tool to push it toward the back of the leaf to create the bevel (Figure 110).

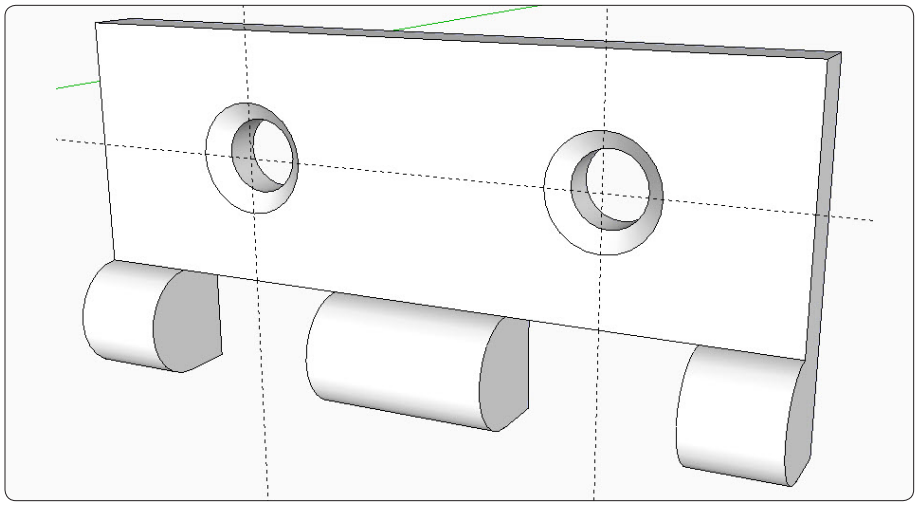


Figure 110. *Make screw holes and give them a bevel.*

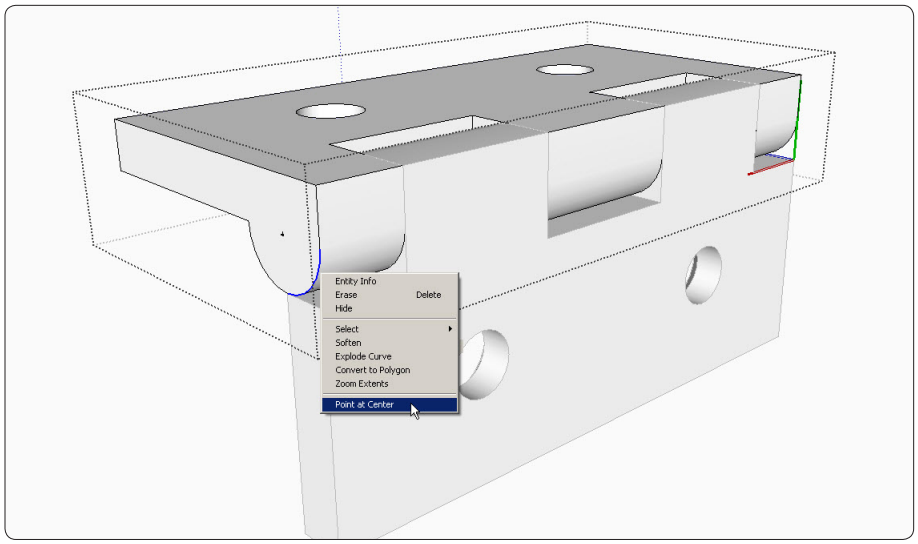


Figure 111. *The completed hinge, partially folded.*

Step 9 Right-click on the arc of the knuckle and choose Point at Center. This places a guide point at the center point of the knuckle. This is helpful to center the Rotate Tool for positioning the hinge. Since each half of the hinge is a separate component, you can rotate it for various positions in the model (Figure 111).

How to Add Color and Texture to Your Model

I don't often need to add color or wood-grain textures to my models. Most of the time, the end product is a set of templates and shop drawings, which are clearer and easier to use if I go easy on the special effects. Adding a texture increases the model's file size, which can affect the computer's performance. However, there are times when it pays to make a model more realistic and appealing: when making a presentation to a customer, for example. Compare the look of the tea table in Figure 1 with the same table in Chapter 10. SketchUp has a built-in capability for sprucing up your models.

However, just as finishing a piece of furniture in the shop takes quite a bit of time, so it is with SketchUp. You can apply a uniform color to a model with a few mouse clicks. Adding realistic-looking wood grain requires more effort.

This chapter explains four ways to use color and wood texture in models. You can also enhance a model's appearance with shadows, a feature in the View menu that's very straightforward. I'll leave it to you to experiment with lighting angles and shadows.

A Simple Application of Color

Occasionally, I apply a light, translucent color to highlight a component or increase the contrast between elements in a model. For example, color helps me quickly see how large a lumber blank I need to bandsaw an irregularly shaped component, such as an arm for a Maloof-style rocker (Figure 2). Rather than use a standard, opaque color, I customize the color I want. Here's how to do that.

Step 1 Draw the lumber blank by creating a rectangle wide and long enough to contain the component, as shown in Figure 3. A default color will automatically fill the face of the blank.

Step 2 Open the Materials dialog box (or the Colors dialog box on the Mac, which you can access by clicking the Paint Bucket icon), as shown in Figure 4. The dialog boxes are different in Windows and Mac computers, but they basically perform the same functions. Use the window in the middle of the box to select Colors-Named. Choose a color from the chart. I like magenta.

Step 3 Because I don't want color in the rectangle to obscure the underlying arm shape, I create a new, less-opaque material. I'll use the magenta but reduce its opacity to about 20 percent. Click on the icon for creating a new material, then use the slider to reduce

Figure 1. *A curly maple finish gives the tea table a more realistic appearance.*

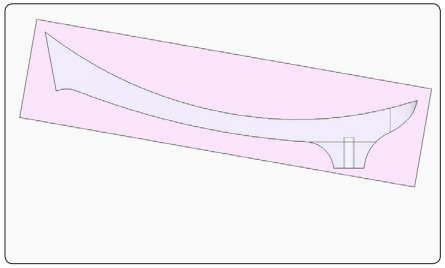


Figure 2. *Color on the lumber blank makes the irregular component stand out.*

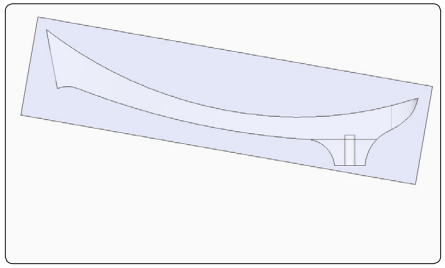


Figure 3. *Draw a rectangle to surround the irregular component.*

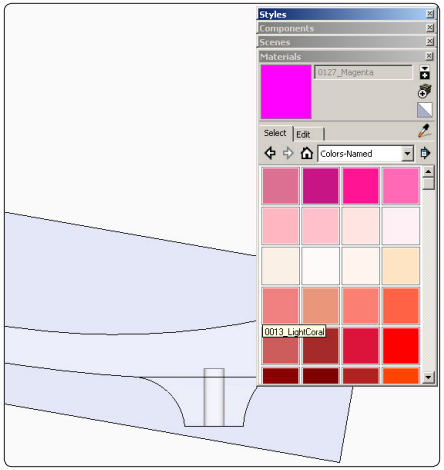


Figure 4. *Open the Materials dialog box and choose a color.*

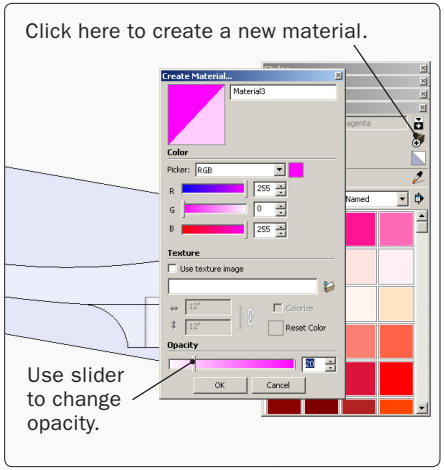


Figure 5. *Reduce the opacity of the color you have selected and designate it a new material.*

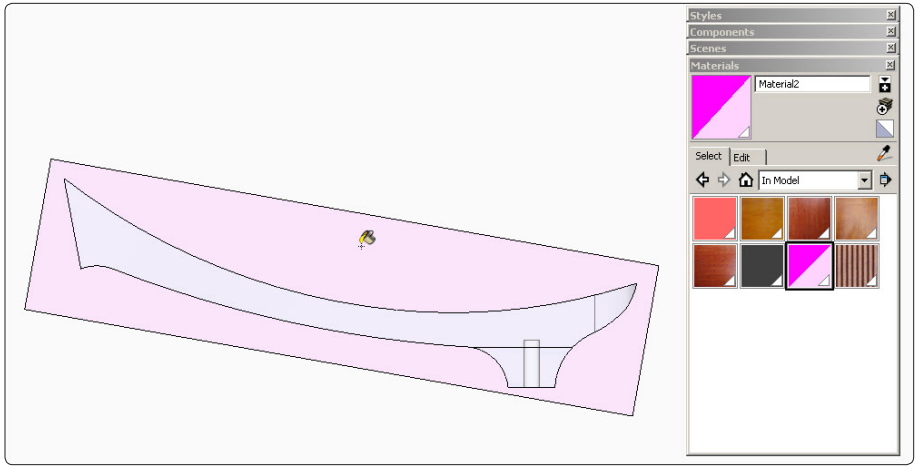


Figure 6. *Use the Paint Bucket Tool to fill the lumber blank with the new color.*

the opacity (Figure 5). When you're finished, click OK.

Step 4 The new material will appear in a square at the top of the dialog box, and the cursor will change to the Paint Bucket Tool. Click the Paint Bucket Tool on the face of the lumber blank to fill it with the newly created low-opacity magenta, as shown in Figure 6.

How to Make Lines or Edges in Different Colors

By default, SketchUp shows all lines or edges in black. Sometimes for clarity it helps to use a second line color. A case in point are the sight lines on a Windsor chair seat. A contrasting color makes them much easier to see.

Step 1 Open the Styles dialog box, as shown in Figure 7. Edit the Edge Settings by clicking on the first cube in the row of five. In the Color window at the bottom of the dialog box, change the setting from All same to By material. Save the changes by clicking the Update Style icon.

Step 2 Open the Materials dialog box and choose a color. Click on the paint chip in the upper-left-hand corner of the dialog box. Open a component for editing and use the Paint Bucket Tool to paint each line or edge you want in the second color (Figure 8). You will have to zoom in close to efficiently paint each line segment. If you click on a face of the component by accident, use the Undo function and try again.

How to Apply a Basic Texture

Textures in SketchUp are images made from photographs. I think it's better to work from photos you take yourself or scan from a book or magazine, rather than try to use one of SketchUp's stock wood textures. Once you import the photo as a texture, you can use it to fill the faces of your model for added realism. Although the process sounds easy, it can be complex.

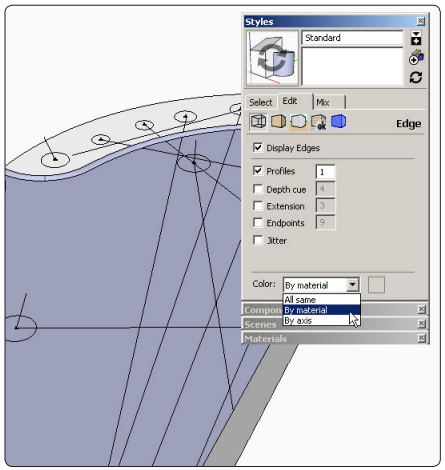


Figure 7. *To make lines appear in different colors, first edit the style for edges to have colors By material rather than All same.*

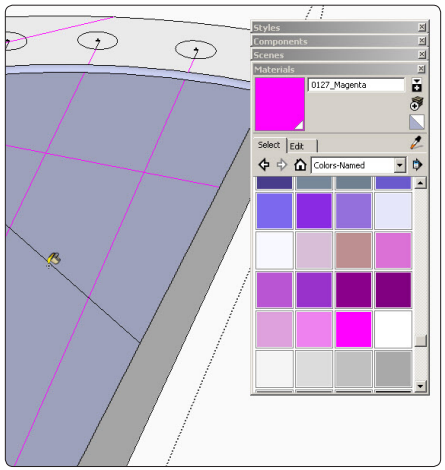


Figure 8. *Use the Paint Bucket Tool to color each line you want in a second color.*

To demonstrate, I'll use the pine Shaker blanket chest shown in Figure 9. My preferred finish for pine is French polish, using seedlac shellac. I do not stain furniture like this, so the color comes from the linseed oil and the dark shellac. I'll use a photo of

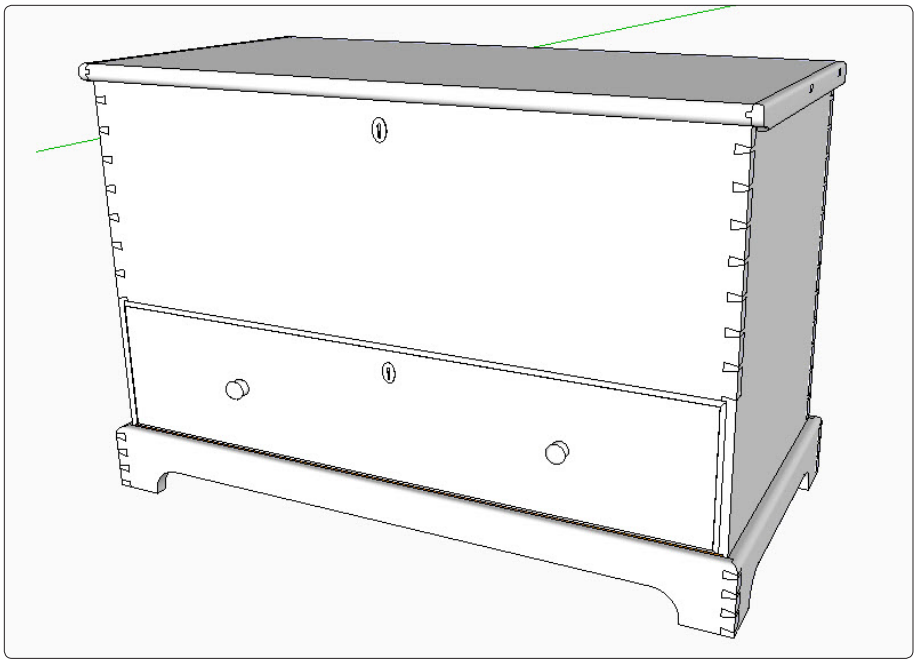


Figure 9. *A pine Shaker blanket chest with default face colors.*

an already finished pine piece (the grain does not have to be horizontal, since you can rotate the picture if needed).

As a rule, I try to paint textures on components without editing them. It's faster and much easier that way, and doesn't affect all the copies of the components in a model. I also apply textures in a separate SketchUp file after I've completed all the modeling, to avoid hampering computer performance.

The only drawback to this method is that I can't edit, move, rotate, or reposition the texture unless I edit the component face. I try to avoid editing the component, but that's not always possible. So I have to resort to texturing within the definition of the component.

Step 1 Locate an existing piece of furniture with the desired grain and finish (or the closest match you can find). Snap a close-up digital photo, focusing on the largest flat area possible, which will help eliminate tiling of the texture. Don't include moldings, handles, hardware, or other obstructions. Figure 10 shows the photograph of the pine finish I used. In Picasa, iPhoto, Adobe Photoshop, or a similar editing program, crop the image, change the brightness or contrast, tweak the color, and make any other necessary adjustments.

Step 2 When you import a texture, it must be placed on a face in the file. Create a separate rectangular face off to the side of the model, making the face at least as large as the largest face you want to paint. As shown in Figure 11, I've drawn a rectangle that matches the overall front face of the blanket chest, not including the drawer.

Figure 10. *Photograph an existing piece that duplicates or closely matches the texture and finish you want. This photo shows the seedlac finish I used on the blanket chest.*

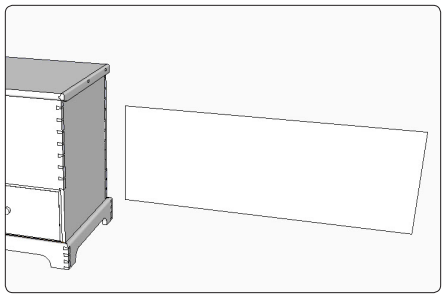


Figure 11. *Create a rectangle on which to place the new texture, making it as large as the largest face to be painted.*

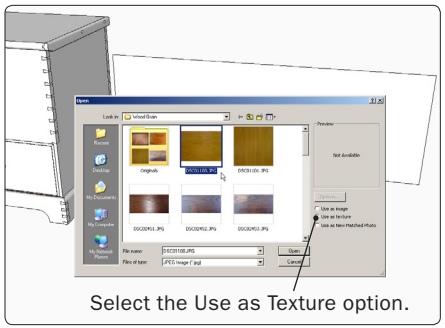


Figure 12. *Import the photo into SketchUp, making it a texture.*

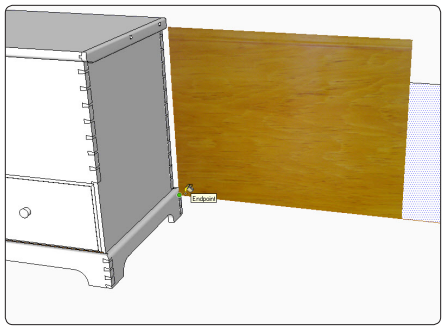


Figure 13. *Anchor the imported texture on the face and move the mouse to resize it.*

Step 3 Click the Menu tab and choose File/Import from the drop-down menu. This opens a dialog box, as shown in Figure 12. Browse to the location of your photos of wood finishes. (I maintain a folder specifically for various wood-grain finishes.) Choose the image you wish to import, select Use as Texture as the import option, and click Open.

Step 4 The image will appear in the modeling window, with a circle that has a line through it at the lower-left-hand corner. Moving the mouse moves the image. As you hover over the rectangle where the texture will be placed, the cursor changes to the Paint Bucket Tool. To anchor the image, click on the lower-left-hand corner of the rectangle face. Begin moving the mouse upward and to the right to size the texture (Figure 13).

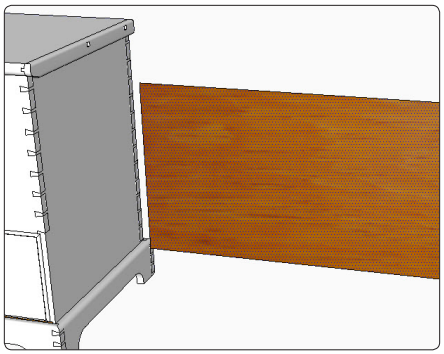


Figure 14. *Size the texture to completely fill the rectangle.*

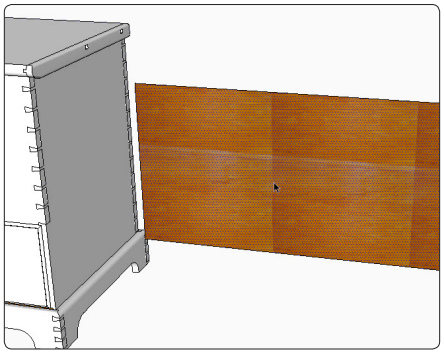


Figure 15. *If the imported image doesn't fill the rectangle, it will be tiled. That leaves unsightly seams.*

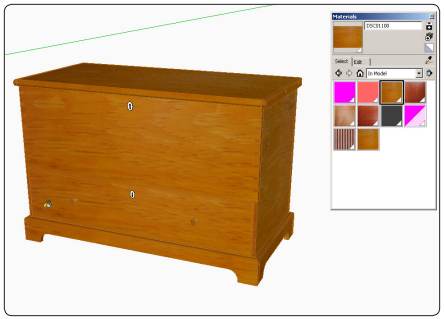


Figure 16. *The blanket chest, with each component painted with the newly imported texture.*

Step 5 Size the texture to completely cover the face of the rectangle, as shown in Figure 14. If you don't, SketchUp places multiple tiles to fill up the space, not a smooth finish (Figure 15). Depending on the size of the original photo, filling the rectangle completely may enlarge the wood grain. You should still have acceptable results, however.

Step 6 The imported texture will appear as a paint chip in the Materials dialog box. Delete the rectangle face. Open the Materials dialog box and click on the pine-grain texture chip just created. The cursor changes to the Paint Bucket Tool. Use it to click on the various components in the model. The texture will cover all the faces of each component. Note that the horizontal grain of the texture works well for this blanket chest, and no editing or rotation is required (Figure 16).

How to Orient Wood-Grain Textures Vertically and Horizontally

The 18th-century mahogany bookcase model shown in Figure 17 needs textures showing wood grain running vertically and horizontally. Here's how to do that without making textures that need to be rotated, moved, or edited.

Step 1 I prefer to finish mahogany with a chemical stain and grain filler, followed by a dark French polish. My first step is to photograph the finish on an existing piece of furniture, as shown in Figure 17.

Options for Editing a Texture

Here's how to edit a texture that is placed within the definition of a component. To illustrate, I'll use the drawer on the blanket chest.

Right-click on the component and open it for editing. Select the Paint Bucket Tool and click on the front face of the component to fill it with texture. As Figure A shows, the thumbnail molding is not selected so it won't be textured. You have to click on each molded edge to texture it.

Figure B shows an ugly tiling line on the drawer face. (Actually, for this example, I purposely caused the tiling by shifting the component's axis toward the center of the component.) You can eliminate the tiling by repositioning the texture. Right-click on the face of the drawer, choose Texture from the pop-up menu, then choose Position from the next menu.

Figure C shows the result when I zoomed out to view the texture pins on each corner of a tile. You can also see the size and position of the tiles. The corner pins are used to edit the texture's position, size, or orientation. The Move (red) pin moves the texture as you drag it with the mouse. The Distort (yellow) pin creates a perspective look to the texture. The Scale/Rotate (green) pin scales and rotates the texture. The Scale/Shear (blue) pin scales and shears, or twists, the texture.

Click the mouse on the red pin and move the mouse to the right until the tile seam disappears from the face of the drawer front (Figure D). Right-click on the texture and choose Done from the pop-up menu (Figure E).

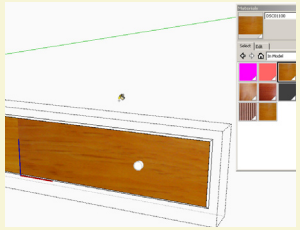


Figure A. *Open the component for editing and click each section with the Paint Box Tool to fill it with texture.*

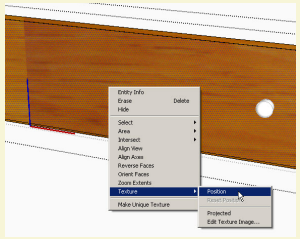


Figure B. *To move or scale a texture, right-click on the component face and choose Texture/Position.*

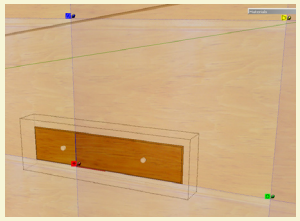


Figure C. *Colored pins at the corners of a tile let you edit a texture in four ways.*

Figure D. *Dragging the red pin moves the tile.*

Figure E. *The drawer front, with the tiled texture moved to improve the overall appearance.*

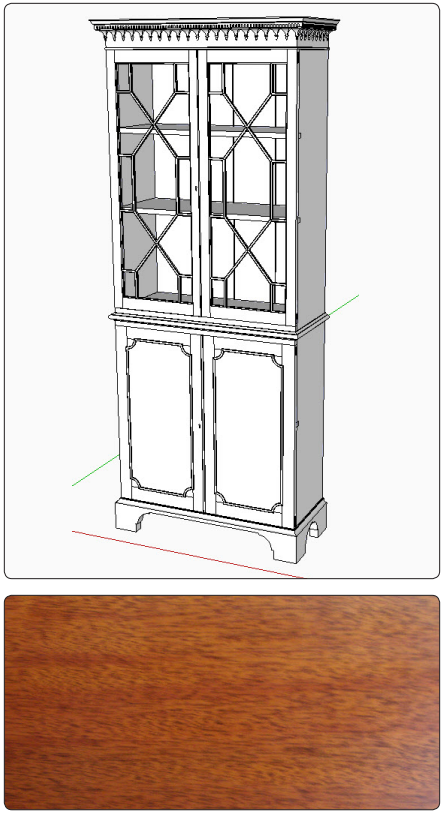


Figure 17. *This bookcase will be textured with the mahogany wood grain shown above.*

Step 2 Create two rectangles—one for the largest face of vertical grain and one for the largest face of horizontal grain (Figure 18). Import the mahogany texture into each of the rectangles.

Step 3 Since the photo showed only horizontal grain, the grain in the vertical rectangle will have to be rotated. Right-click on the texture of the vertical rectangle and select Texture/Position from the pop-up menu, as shown in Figure 19.

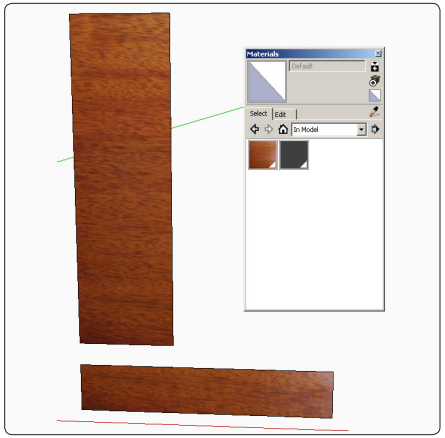


Figure 18. *Create rectangles for the largest areas of horizontal and vertical wood grain.*

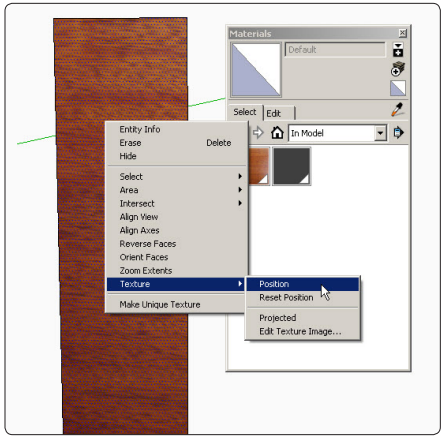


Figure 19. *Use the Texture-Editing function to reorient the grain vertically.*

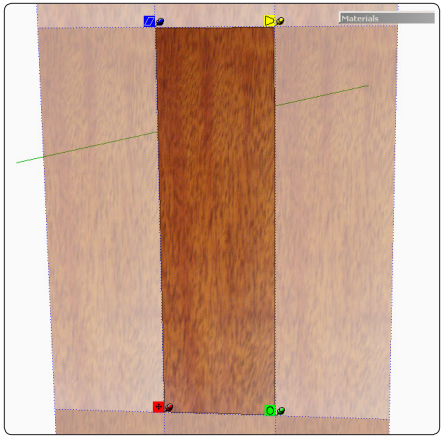


Figure 20. *The green pin lets you to rotate and reposition the grain.*

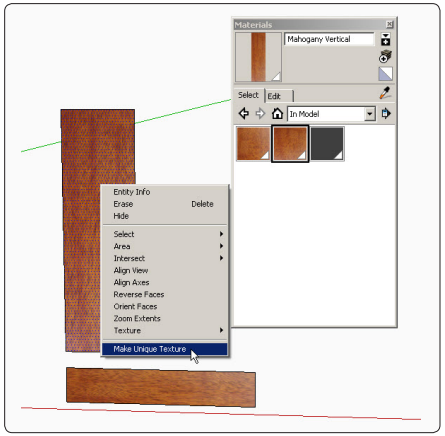


Figure 21. *Make the vertical texture unique.*

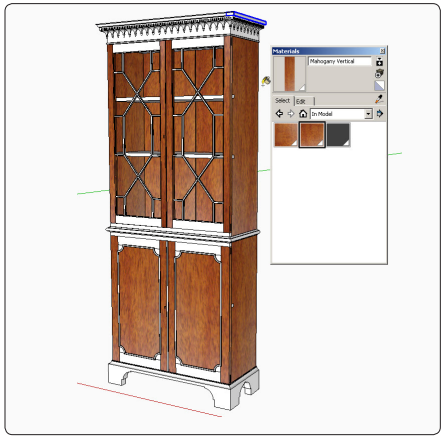


Figure 22. *Apply the vertical-grain texture to all the appropriate faces, then do the same for the horizontal-grain faces.*

Figure 23. *The completed model and its real counterpart.*

Step 4 Use the texture corner pins, primarily the green one, to rotate the grain so that it's vertical (Figure 20).

Step 5 Right-click on the vertical texture and choose Make Unique Texture from the pop-up menu, as shown in Figure 21. In the Materials dialog box, change the names of the two mahogany textures.

Step 6 Click on the vertical grain texture in the Materials dialog box. Use the Paint Bucket Tool to click on all the vertical grain faces in the model (Figure 22). You don't have to open the components for editing. Do the same for all the horizontal grain faces.

Figure 23 shows the fully textured model and the actual bookcase. As you can see, careful selection and placement of grain textures can produce a very convincing, realistic model.

How to Create an Effective Package of Shop Drawings

When I began using SketchUp, I remember reading that it was useful only as a conceptual design tool and that it couldn't produce detailed shop drawings. That stated limitation puzzled me. I was having great success with the program, especially in generating very good detailed documents for my own shop work as well as for my students. I never had it so good.

The key to generating shop drawings with SketchUp is its Scenes utility, which allows you to define, capture, and save multiple views and details. When you print them, you have a comprehensive document to use in the shop.

I'll use the Connecticut stool from Chapter 3 to illustrate how to create a drawing package. Open the stool model again to work through the steps shown in this chapter.

How to Make and Modify Scenes

As I create a model, I continually develop views that I will need in the shop. I don't differentiate modeling tasks from developing documentation. Those activities are inseparable. Even so, I often begin woodworking and find that it would help to have another specific view: cross section, x-ray, or close-up. I keep a computer handy to the shop so I can quickly generate the new view.

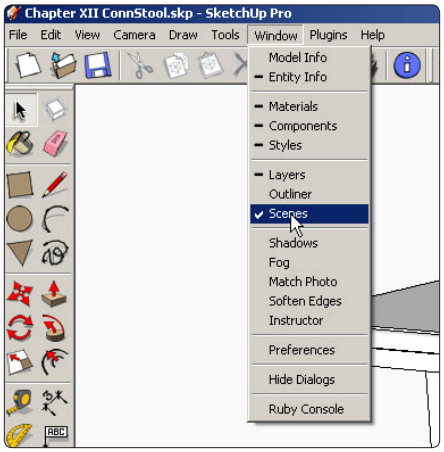


Figure 1. *Opening the Scenes dialog box.*

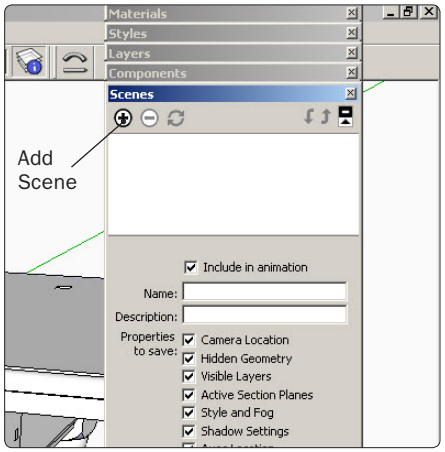


Figure 2. *The Scenes dialog box.*

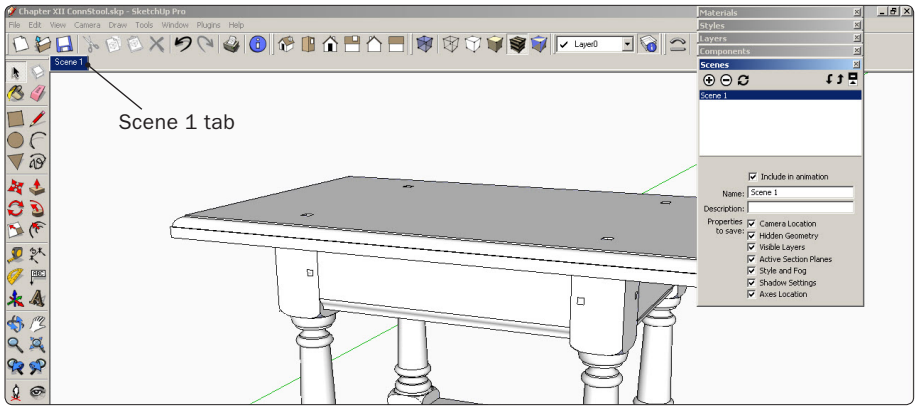


Figure 3. *Open a new scene.*

If you don't have the Scenes dialog box bundled on-screen with other functions, as explained in Chapter 2, click on the Window tab in the Menu Bar, then on Scenes in the drop-down menu (Figure 1). This displays the Scenes dialog box shown in Figure 2. (The check boxes at the bottom of the Scenes dialog box allow you to have SketchUp save or remember various properties. I just check them all.)

Click on the Add Scene icon to open a new scene, as shown in Figure 2. SketchUp adds a tab labeled Scene 1. You will also see Scene 1 identified in the Scenes dialog box. Click on the Name text box and name the scene Assembly, as shown in Figure 4. The name changes on the tab and in the dialog box.

Click on the Update Scene Icon, the icon of arrows chasing each other, to save the Assembly scene of the stool. This saves the current view shown in the modeling window.

After clicking the Update Scene button, another pop-up menu appears. Click the Update button within this menu as well. Every time you update a scene, it takes two clicks.

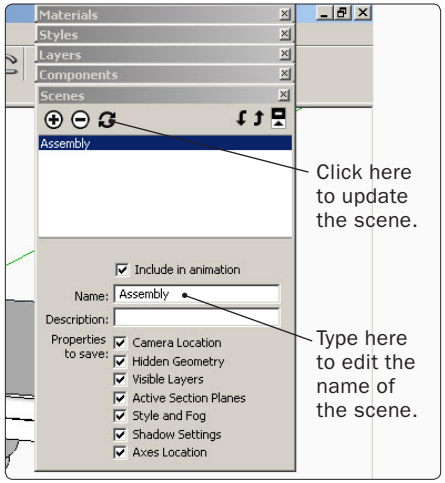


Figure 4. *Edit the name of the scene and update.*

If you modify the view in a scene by using the Orbit, Pan, or Zoom Tool, you can easily update the scene. Open the Scenes dialog box, click on the title of the scene, and click on the Update Scene Icon.

Now you have an easy way to return to this saved view with just a click of the mouse. By creating additional scenes—showing various parts, zoomed-in views, different angles, orthographic view, exploded view, or X-Ray view—you build a complete and comprehensive design package.

My Standard Scenes

Over the years, I've developed a fairly standard methodology for setting scenes, one based mainly on personal taste. With practice, you will find your own optimum set of scenes. To help you get started, here's a rundown of the scenes I normally used:

- **Assembly** The overall assembly, sometimes with dimensions for overall length, width, and depth.
- **Exploded View** I pull the model apart and display the name of each component.
- **Orthographic** A top, front, and end view in orthographic projection, with dimensions. I often use the X-Ray face style to show joinery.
- **Component Perspective** Each component will have at least one scene, a perspective view with dimensions.
- **Component Template** Many components need orthographic front, side, or top views. These scenes are frequently used to create full-size templates. I often use the X-Ray face style for these scenes to show joint details.

I used 11 scenes for the Connecticut stool, which included those listed above, plus a cutting diagram. For more complicated pieces, I may have as many as 50 scenes.

The Exploded View

I think the question I'm asked most often is how to make an exploded view in SketchUp. Ironically, this is one of the easiest things to do, assuming you built the model with components. You only need to use the Move/Copy Tool. It takes about a minute to generate an exploded view, even for a complex assembly.

Select the fully assembled model and use the Move/Copy Tool to make a copy and move it off to the side. (I usually move it to the right along the red axis.)

Use the Move/Copy Tool to pull apart the furniture pieces and arrange them to suit.

Use the Text Tool to the right of the Protractor Tool in the Large Tool Set to label each component. When you click the Text Tool on the component, SketchUp displays the default label text, which is the exact name you gave the component. If you don't like the default label, you can modify by double-clicking the label and editing with the keyboard.

Once you have the components in the copy separated and labeled to your liking, make that view a new scene, labeled Exploded View.

The Orthographic View

I prefer to include a straight-on front, side, and top view in the final documentation. To create this scene, make another copy of the assembled model and move it down the red axis. Copy it again and move the second copy to the side, being sure to stay on the red axis. Go back to the first copy, making a third copy and raise it up along the blue axis. Use the Move/Copy Tool to rotate each assembly 90 degrees, placing it into its respective top or end orientation, as shown in Figure 6.

It helps to make the overall model a named component. That way, any adjustments and changes to the overall model automatically appear in all copies in the design file. Don't worry about lining up the assemblies on the green axis. The front view will look down the green direction so displacements along that axis won't matter.

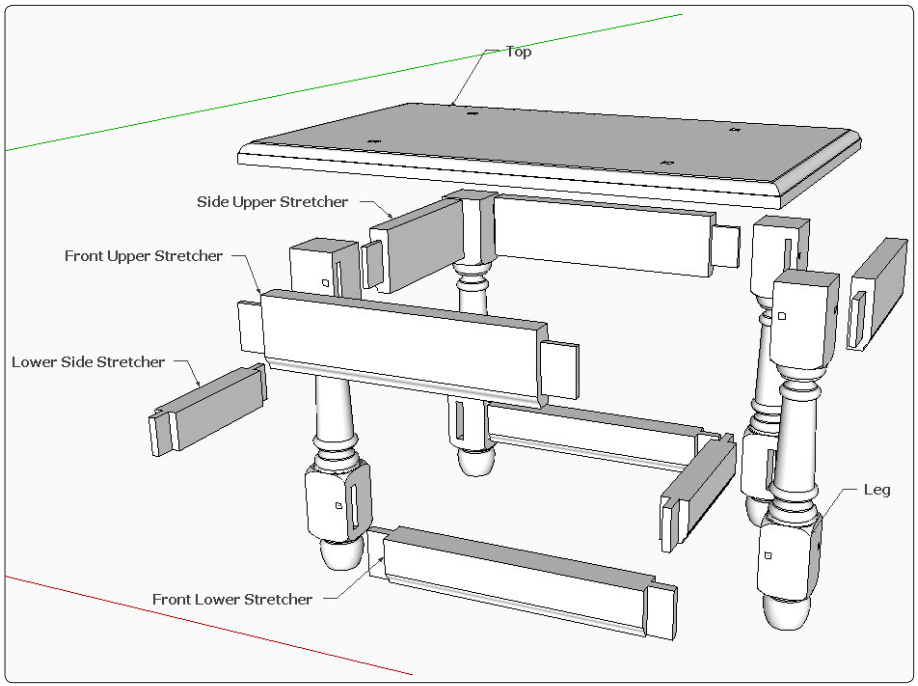


Figure 5. *To make an exploded view, move components apart and label each one.*

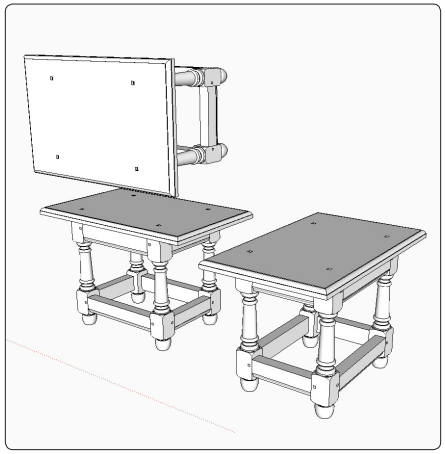


Figure 6. *To make an orthographic drawing, rotate copies of the assembled piece for front, top, and side views.*

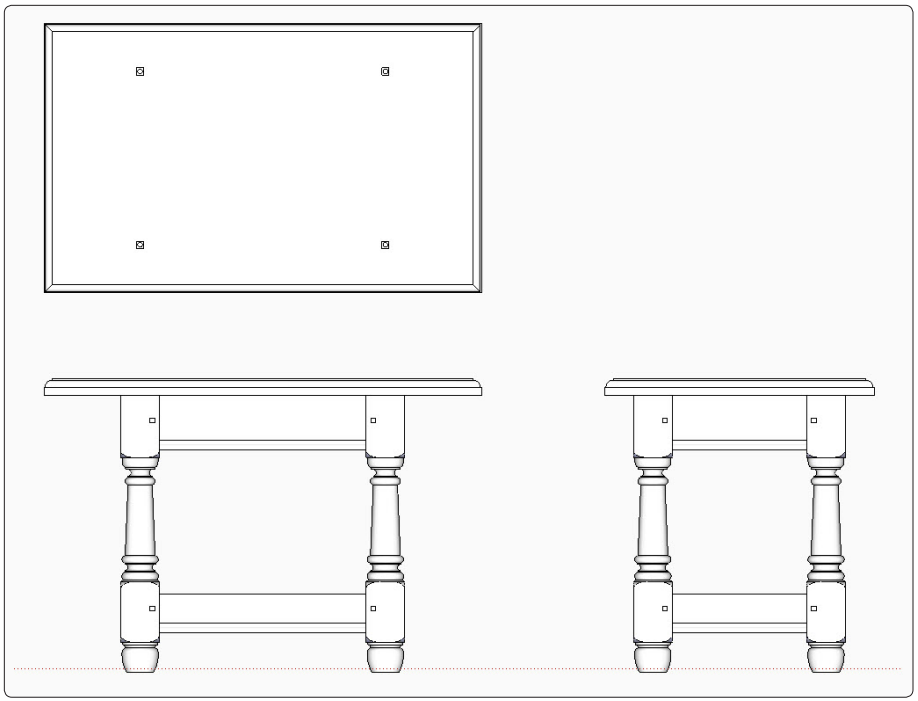


Figure 7. *With the Camera set to Parallel Projection, the three copies appear as two-dimensional drawings.*

Click on the Camera tab in the Menu Bar. From the drop-down menu, choose Front for the standard view and choose Parallel Projection. Figure 7 shows the resulting view. You may need to nudge one or more of the assemblies with the Move/Copy Tool to space it appropriately. Be sure to keep the moves on-axis.

Open the Scenes dialog box, create a new scene, name it Orthographic, and update the scene. You should have three scene tabs now: Assembly, Exploded, and Orthographic. Click on each tab to switch between the three views.

I prefer to use X-Ray face style in my orthographic views because it shows hidden geometry and joinery. This is the SketchUp version of using dashed lines to indicate hidden parts. (The new Back Edges view in SketchUp 8 serves the same purpose.) Clicking on the X-Ray icon in the Face style toolbar will change the view, but only temporarily. To have an X-ray or Back Edges view whenever you select the orthographic scene tab requires some additional set-up with Styles. Here's what to do.

Open the Styles dialog box, as shown in Figure 8. There is only one style in the file, the Shaded With Textures default style. You need to create a new style for the X-Ray face setting.

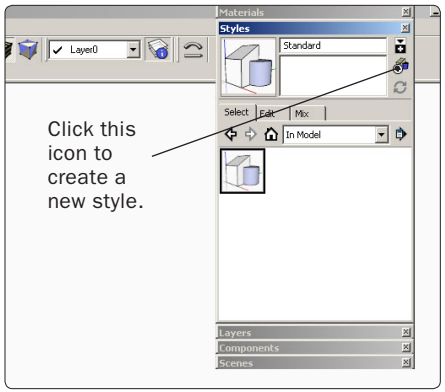


Figure 8. *To change the face style for a scene, begin by opening the Styles dialog box.*

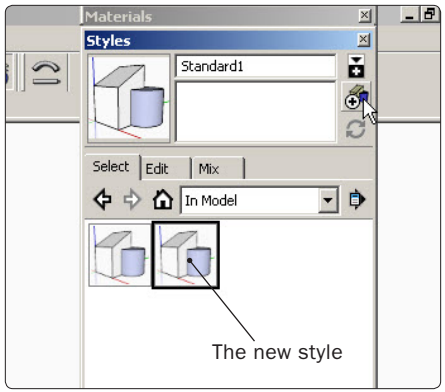


Figure 9. *When the new style icon appears in the new dialog box, click the Edit tab.*

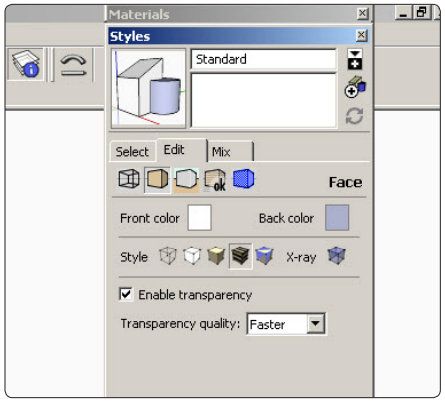


Figure 10. *When the Edit tab opens, choose X-Ray view and change the style label.*

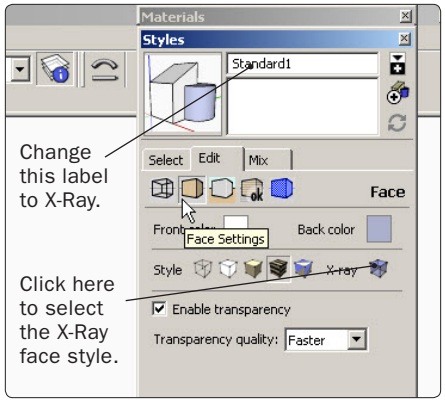


Figure 11. *As soon as you update the style, the orthographic view changes to X-Ray.*

Click on the icon for creating a new style, as shown in Figure 8. A new style thumbnail will appear, as shown in Figure 9. Click on the Edit tab. The Styles dialog box will change to the edit page, as shown in Figure 10. Click on the second cubic icon from the left, for Face Settings. Note the face styles shown midway down the dialog box. Click on X-Ray style to change the selection. In the text box at the top of the dialog box, change the name of the style to X-Ray, as shown in Figure 11. Click on the Update Styles icon to save the changes to this new style. The orthographic view will immediately change to X-Ray.

There is one more very important step to finalize the scene change to X-Ray style. Open the Scene dialog box and click on the Update Scene button, as

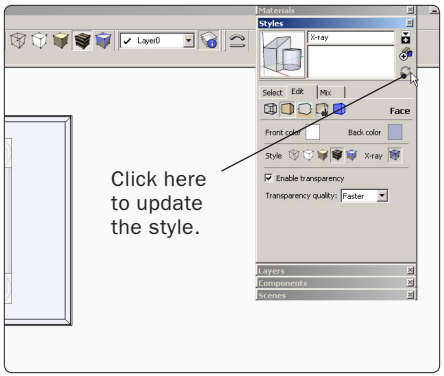


Figure 12. *Update the scene so that it always opens in X-Ray view.*

shown in Figure 12. Now the X-Ray style is attached to the Orthographic scene. Whenever this scene is selected, the view will be in X-Ray.

Dimensions

The Dimension Tool, shown in Figure 13, is quite intuitive and simple to use. Click on one end of an object to start the dimension, then move to the other end and click again. The dimension lines will appear with the text value based on whatever format settings you have chosen.

Here is the only tricky part: As you move the mouse, the dimension lines move, too. You can decide where the dimension will finally be placed by clicking the mouse again. Depending on your view of the model, the dimension can be placed along the red, blue, or green axis. You can also place a dimension parallel to an angled component. As you move the mouse and the dimension lines, you will see a red, green, or blue dotted line appear. It tells you which axis the dimension is aligned with (Figure 13).

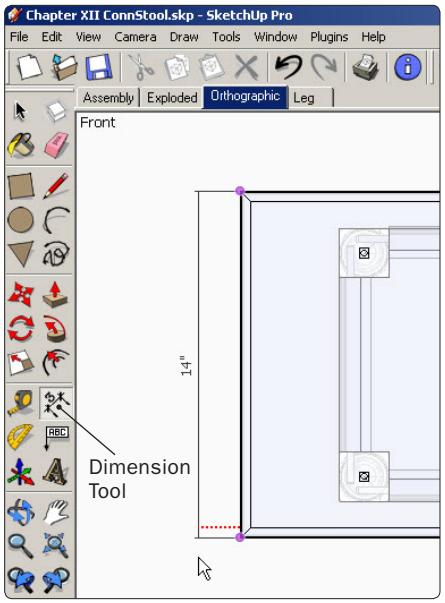


Figure 13. *When you place a dimension, a colored dotted line appears, to indicate which axis the dimension is on.*

If you don't like the way a dimension appears, then use the Orbit Tool and try again. The options for placing a dimension very much depend on the current view. With an orthographic drawing, though, placing dimensions will be very straightforward.

Here are some general recommendations for placing dimensions:

- Don't place dimensions within the definition of a component. If they are included within the definition, then they will appear in every copy of the component, cluttering your scenes.
- In general, dimensions on Layer 0 (the default layer) will work. However, this will likely require you to create more copies of components (each with a separate scene) to isolate dimensions specific to the views. For example, the detail dimensions shown for a close-up view will be unreadable in the zoomed-out overall view of the component. So you would need to have one copy of the component for the close-up detailed view and another for the overall view.
- I find it useful to apply dimensions to layers that are assigned to typical camera views. That gives me more control over which dimensions are displayed when I have more than one view for the same component. I set up five layers within my SketchUp template: 1. Detail View Dimensions/Text, 2. Perspective View Dimensions/Text, 3. Front View Dimensions/Text, 4. Side View Dimensions/Text, 5. Top View Dimensions/Text.
- By using these alternative layers for dimensions and call-out text, I can have five different views of the same component, all showing the dimensions in the clearest, most appropriate way.
- In general, I use the Text Tool to indicate dimensions of circles, arcs, and holes. You can use the Dimension Tool instead, but only within the definition of a component. And that may cause issues with dimensions showing up in unwanted places.
- When dimensioning, zoom in closely to make sure you are connecting to the proper place on a component. From far away, the dimension may attach to a point close by but not exactly where you want it to be.
- After placing dimensions, carefully inspect their placement. Be sure that they are on the proper axis and between the correct endpoints.

There are various ways to change how dimensions are displayed. You can find many of those in the Window/Model Info/Dimensions dialog box. You can also change the way dimensions are displayed on the fly by right-clicking on them. I often do this to place the numbers outside the start or end of the dimension line. See the 1½ in.dimension in Figure 14. After you place a dimension, you can shift its location with the Move/Copy Tool. That moves it along the existing axis but won't change its axis orientation.

The Dimension Tool can also be used to nudge and bump the location of a previously placed dimension. As you hover the tool over the dimension, it is

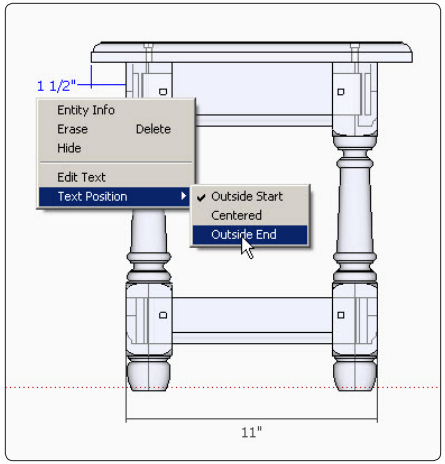


Figure 14. *Right-click on a dimension to change its position on the model. Here, the dimension highlighted in blue has been moved outside the endpoint for better legibility.*

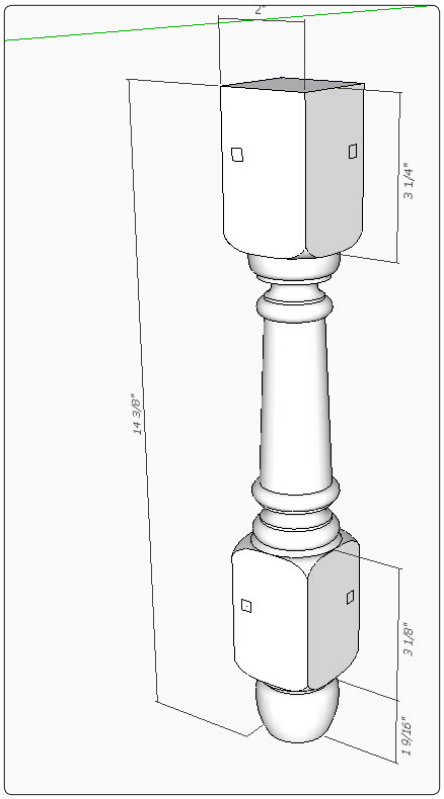


Figure 15. *Use the leg to practice making a scene for a component. Place it as shown and add dimensions.*

automatically selected; the cursor changes to the Move/Copy shape.

Make a Component Scene

Copy one of the leg components in the Connecticut stool and move it down the red axis. Arrange a perspective view similar to the one shown in Figure 15. Open the Scenes dialog box and make a new scene called Leg. Update the scene. Place overall dimensions like those shown in Figure 15. This is a challenging component to dimension. Use the Orbit Tool on the component and watch the color of the dotted lines to be sure dimensions are properly aligned.

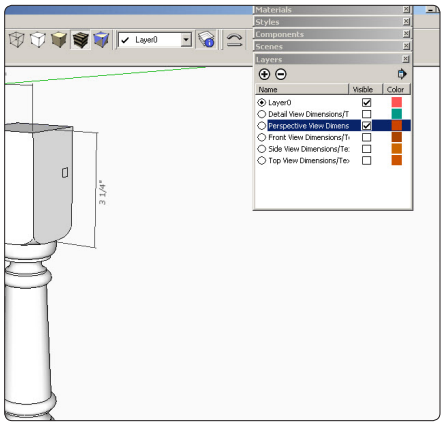


Figure 16. *Open the Layers dialog box to create a new layer for the dimensioned leg component.*

Open up the Layers dialog box, as shown in Figure 16, and click on the box to place a check mark on the Perspective View Dimensions/Text layer. Be sure that the only other check mark is on Layer 0. That is the default layer. Don't change it.

Open the Scenes dialog box and update the scene. If you don't do this, the layering of dimensions will not work as intended. With the Scene updated, only Layer 0 and Layer Perspective graphics will be displayed in that specific scene.

The dimensions you placed on the leg are currently on Layer 0. To change the layer for these dimensions, use the Select Tool, hold down the Shift key, and click on each dimension in turn to highlight them, as shown in Figure 17. Now click on the Layer Toolbar and select Perspective View Dimensions/Text. This shifts all the selected dimensions from Layer 0 to the perspective layer. This procedure doesn't change the default layer.

If you reverse the process, picking a layer on the Layer Toolbar first, you will change the default layer. You'll probably forget that happened and end up with a mess of graphics on unintended layers.

Create a Template View

One of the wonderful byproducts of SketchUp is the ability to make full-size templates. My students and I regularly print these templates and use them extensively in the shop. Here's how to make a template.

With the Perspective View of the leg on the screen, click on the Front icon in the Standard Views toolbar. Click on the Camera tab in the Menu Bar, and choose Parallel Projection from the drop-down menu. Change the face style to X-Ray.

Open the Scenes dialog box, add a new scene called Leg Template, and update the scene. You should now have a view and a saved scene like the one shown in Figure 18.

We need to add more detailed dimensions to this template view, but we don't want the new dimensions to show in the overall perspective Leg scene. To do that, open the Layers dialog box, click the Front View Dimensions/Text layer, and unclick the Perspective View Dimensions/Text layer. Open the Scenes dialog box and update the Leg Template scene. Place the new detailed dimensions and select them with the Select Tool as you hold down the Shift key.

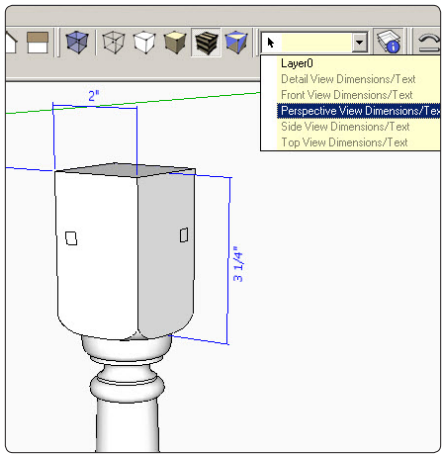


Figure 17. *To change the layer for the dimensions, first highlight them, then open the dialog box in the Layers dialog box, and choose the layer you want.*

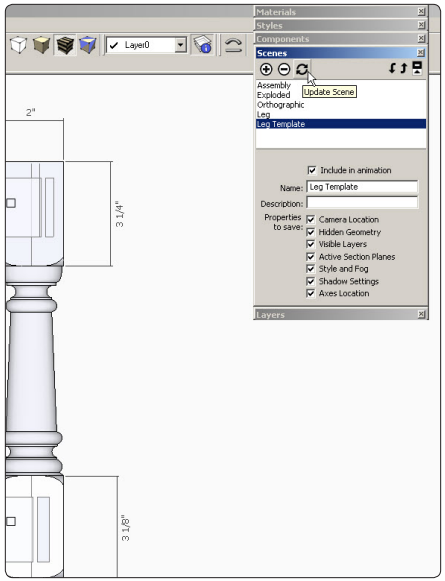


Figure 18. *To make a full-size template, change the view to Parallel projection and the face view to X-Ray to show hidden joinery. Then create a new scene.*

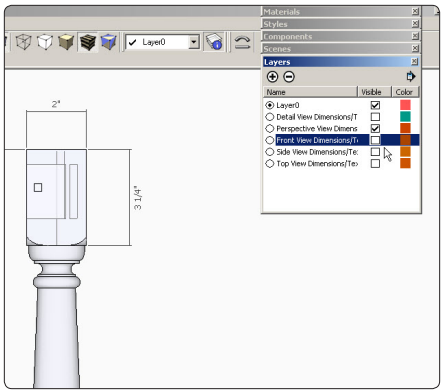


Figure 19. *Select the overall dimensions and change the layer on which they appear, so that they don't show up on the template scene.*

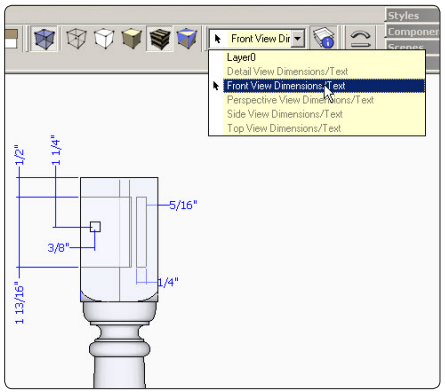


Figure 20. *For the template view, place the necessary detailed dimensions, then place them on the proper layer so that they appear only on the template.*

Click on the Layers Toolbar, and choose the Front View Dimensions/Text layer (Figure 19).

To check how you've done with the layering of dimensions and the different face styles, click on alternate scene tabs. You can use these same procedures to create unique scenes for the other components.

Create a Cutting Diagram

Here is another scene that I use often. It helps me choose lumber planks for a specific project.

First, lay out plank sizes for the various thicknesses of lumber needed for the piece, using widths likely to be available for the wood you plan to use. Figure 21 shows the planks in blue.

Next, copy an assembled model and move it close to the planks. Use the Move/Copy Tool to pull each component from the model, then rotate it for a flat layout on top of the plank. Move it into position on the respective plank, as shown in Figure 21. Once you've placed all the components, rearrange them as needed for the most efficient layout.

With a popular, free plug-in called CutList (available as a download at www.box.net/shared/ce18vpk36l), you can develop a cut list based on the model components (Figure 22). Select the overall assembly of the model, click on the Plugins tab in the Menu Bar, and choose CutList (Figure 23). A dialog box opens, allowing you to customize the output. I choose an option to produce a CSV file. Open the cut list in a spreadsheet program and edit as needed.

After producing the various scenes, click on View Extents. You should see a screen like the one shown in Figure 24. Each black blob on the screen is a specific scene, showing a component or assembly with dimensions and text. This also illustrates how the copied components are strung along the red axis and spaced to avoid any overlap.

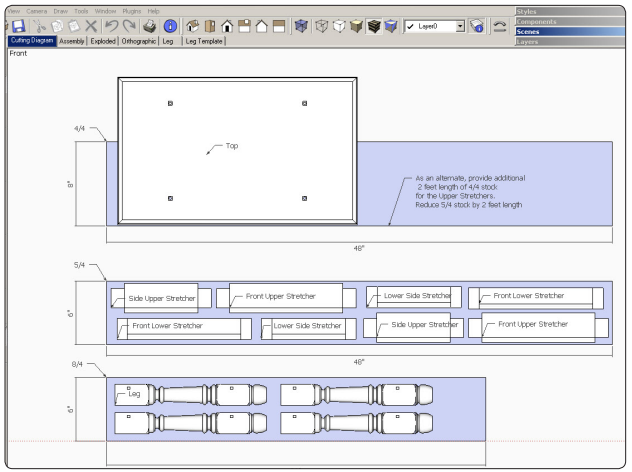
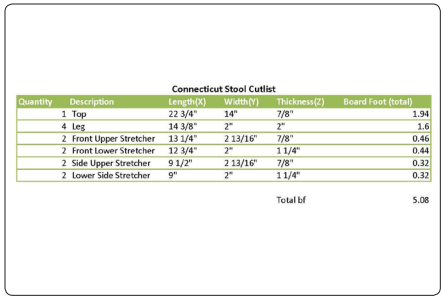


Figure 21. *To create a cutting diagram, rough-in plank sizes (shown in blue) for each thickness needed, then overlay each component on the appropriate planks. Move the components around until you're satisfied that you have the best arrangement.*



Connecticut Stool Cutlist

Quantity	Description	Length(X)	Width(Y)	Thickness(Z)	Board Foot (total)
1	Top	22 3/4"	14"	7/8"	1.94
4	Leg	14 3/8"	2"	2"	1.6
2	Front Upper Stretcher	13 1/4"	2 13/16"	7/8"	0.46
2	Front Lower Stretcher	12 3/4"	2"	1 1/4"	0.44
2	Side Upper Stretcher	9 1/2"	2 13/16"	7/8"	0.32
2	Lower Side Stretcher	9"	2"	1 1/4"	0.32
			Total bf		5.08

Figure 22. *A free plug-in allows you to make a cut list for the project, based on the specific components in the model.*

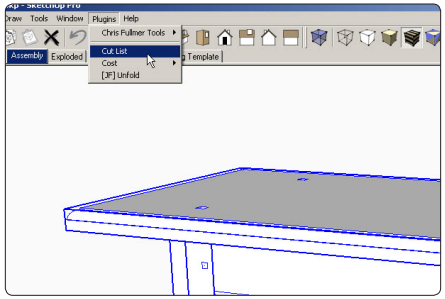


Figure 23. *Select all the graphics in an assembled model, then select the CutList plug-in from the drop-down menu to generate a cut list for the project.*

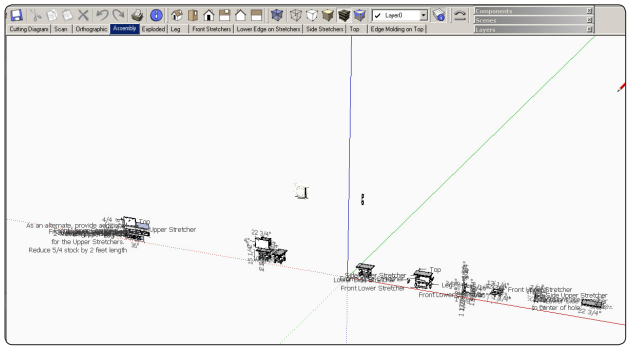


Figure 24. *After you've created all the scenes you need, click the Zoom Extents Icon to see how all the scenes are arranged along an axis.*

Printing Full-Size Templates and Other Scenes

It's nice to have digital data, but you still need paper to take to the shop. With SketchUp, each printed page corresponds to one saved scene. Except for full-size templates, the number of pages equals the number of scenes in the SketchUp model. Because of their size, templates require multiple sheets; the trick is to print them without wasting paper.

I'll explain how to set up scenes and templates to print on Windows computers first, then on Macintosh computers. "Templates Using SketchUp Pro and Layout" on page 136 covers the expanded printing options available with the for-pay version of SketchUp.

Background on Templates

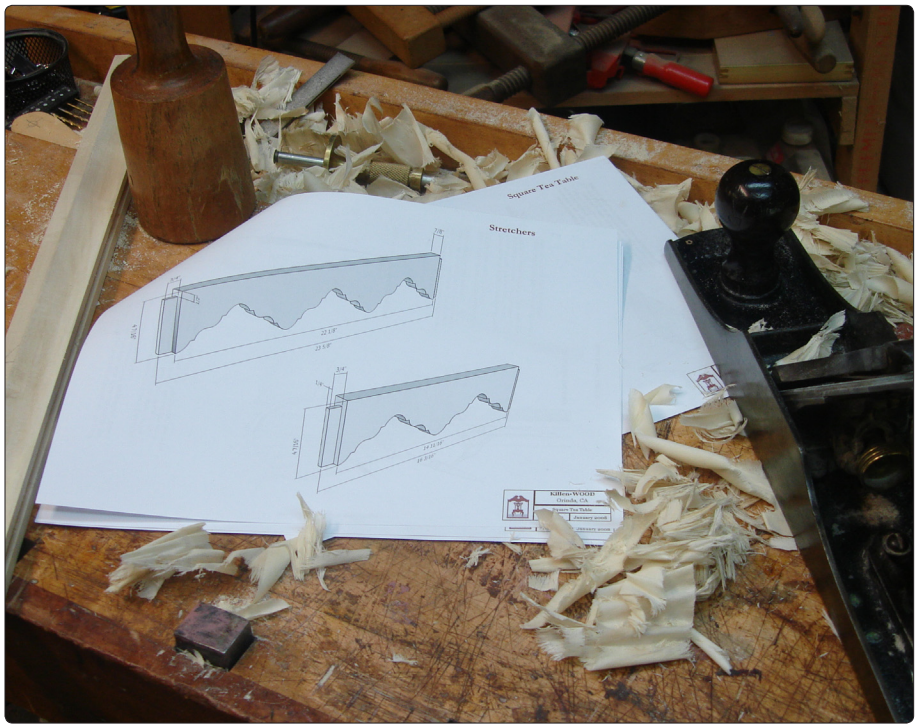
My passion is reproducing period furniture. I marvel at the beauty and function of these styles and love the challenge and feeling of accomplishment with each piece I make. I try to replicate the original as closely as possible, including complex joints and intricate carvings. It would be a luxury to have access to the originals, but I have to rely on photos and a library of furniture books.

There is only so much information you can get from a photo and drawing. I'm often squinting at images through a magnifying glass to figure out a joint. Some details are just not available, so I make my best guess, fill the gaps, and work up a comprehensive model in SketchUp. If you can't have the original piece in your shop, having a detailed 3D design model is just the next best thing.

The model also makes it easy to create full-size templates of irregularly shaped components. I use templates in every project, continuing a practice common in historic cabinet shops. Early craftsmen made extensive use of templates to reproduce the shapes, curves, carvings, and angles of their furniture.

There is probably no better display of 18th-century patterns than that of the Dominy Tool Collection in East Hampton, New York. The book *With Hammer in Hand* (The University Press of Virginia, 1968) presents many examples of patterns used in the Dominy woodshops from 1770 to 1840. The book also refers to patterns used at Winterthur and Old Sturbridge Village. I have seen similar patterns hanging on the walls of the cabinetmaker's shop at Colonial Williamsburg.

Modern-day woodworkers use templates and patterns too, of course. As Lonnie Bird says in *Shaping Wood,* (The Taunton Press, 2003) "Good patterns are one of the keys to good curves." In *American Furniture of the 18th Century* (The Taunton Press, 1996), Jeffrey Greene advises modern cabinetmakers "to make full-size drawings on poster board or similar heavy stock. This drawing can then be cut to serve as patterns."



It's hard to do good work in the shop without having a good set of plans.

That's exactly what I do with the templates I create in SketchUp. Figures 1, 2, and 3 show the templates I made for three reproductions. Some components require more than one template. The top rail of the Windsor chair, for example, requires separate templates for the straight blank before bending, a bottom view for spacing the spindle sockets, and another after bending for spindle socket angles.

After printing the templates on multiple pages, I trim the pages and tape them

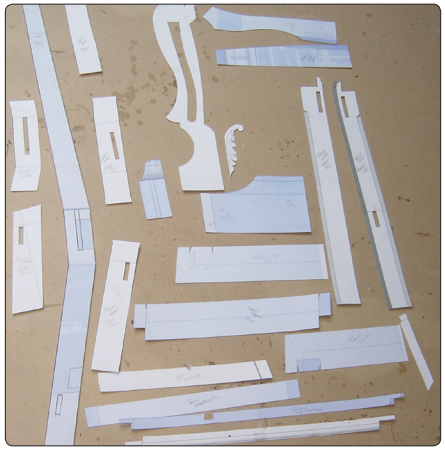


Figure 1. *The templates I use to make a Williamsburg Chippendale chair.*

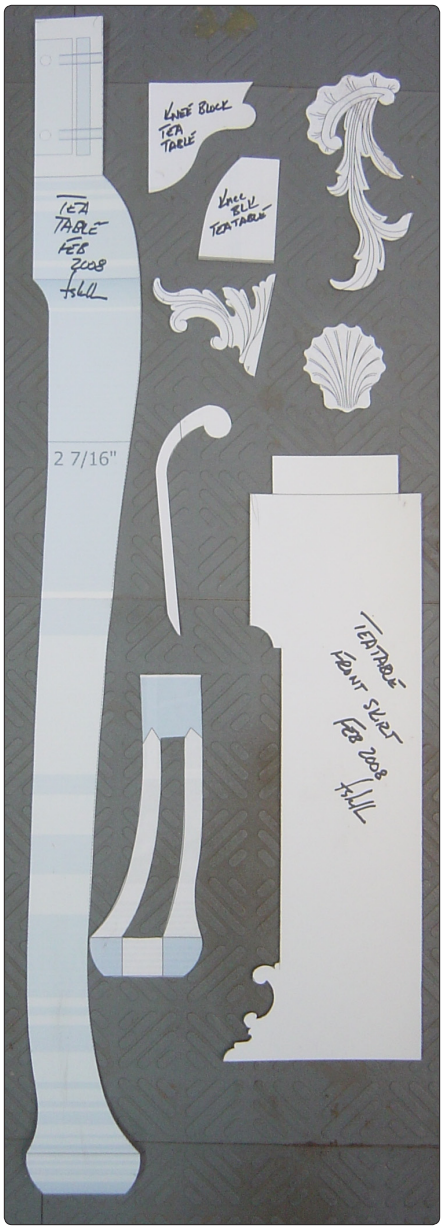


Figure 2. *Templates for the legs and carvings on a tea table.*

together end to end. I then coat the taped-together pages with a glue stick and paste them to poster board. Then, with an X-Acto knife, I carefully trim the shapes and joint details, as shown in Figure 4

I generally print templates in X-Ray face style to make hidden joinery visible and to allow me to mark up the lumber.

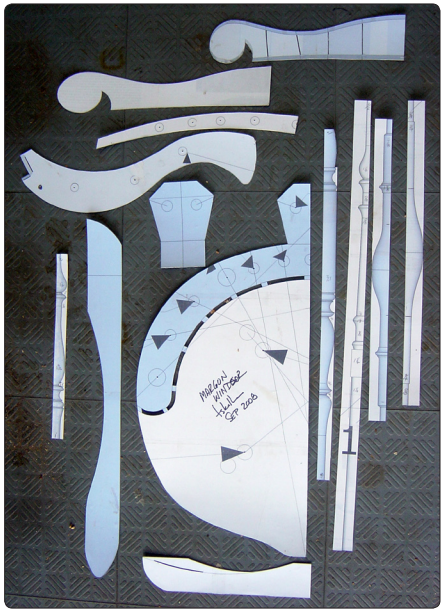


Figure 3. *Templates for a Windsor chair.*

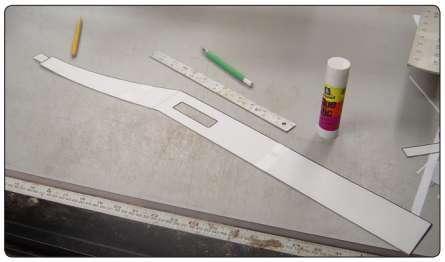


Figure 4. *To make a template, I piece together the printouts, paste the result onto poster board, and then carefully trim it.*

The Windsor chair arm shown in Figure 5 is a good example. The arm joins to a splayed stile that connects into a socket at the rear of the seat. The joint is made at a compound angle. In SketchUp, the connection is detailed enough to show the required angle of the faces of the joint. So I can use the template to mark out accurate cutting locations on both faces of the arm (Figure 6).

The templates for a Windsor chair seat include the sight lines for the angled seat sockets. I use a template to mark the sight lines on the top surface of the seat for accurate drilling, as shown in Figure 7.

Print Setup for Windows

Click on the File tab in the Menu Bar and click on Print Setup. This opens the Print Setup dialog box, as shown in Figure 8. Select the printer you will use, then set up the page size, source, and page orientation. My preference is landscape, as this fits well with the computer screen. Click on the OK box when you have finished.

Click on File in the Menu Bar again; this time, select Print Preview to open the Print Preview dialog box, as shown in Figure 9. I prefer using Print Preview because it gives me a chance to see the results before committing to print and possibly wasting paper. This dialog box gives you the option to print the current view, all pages, or any range of the saved scenes. For Print Size, check Fit to Page for general printing. Uncheck it when printing full-size or scaled drawings. For furniture-type SketchUp files with multiple scenes, unclick the Use

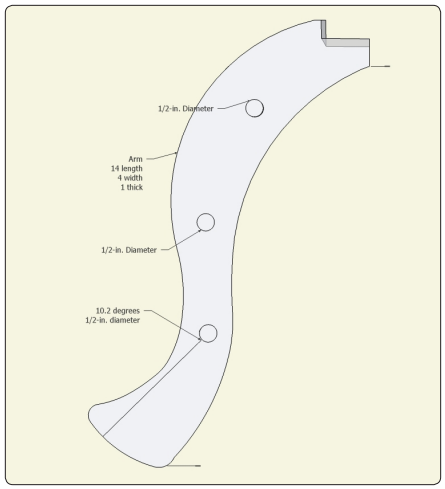


Figure 5. *Templates like this for a Windsor chair arm not only include notes about construction details, but also hidden joinery.*

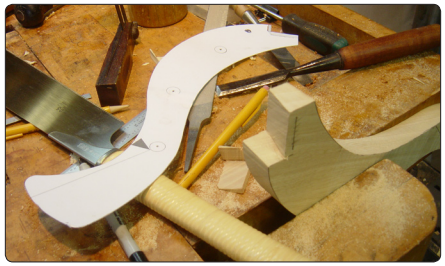


Figure 6. *The hidden joinery on the template lets me mark accurate cutting locations.*

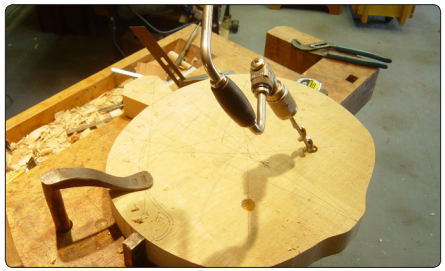


Figure 7. *Sight lines transferred from the template to the seat help me drill the sockets at the correct angles.*

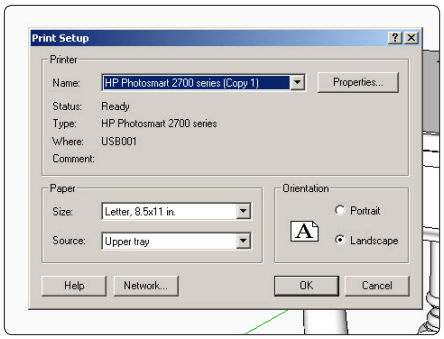


Figure 8. *The Print Setup dialog box in Windows.*

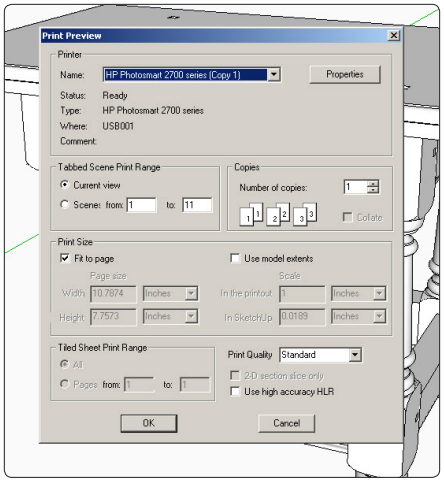


Figure 9. *The Print Preview dialog box in Windows.*

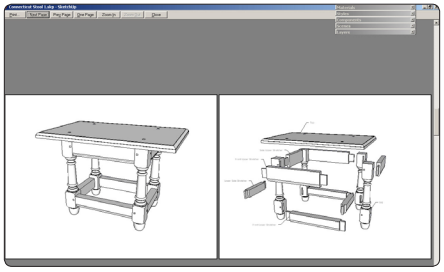


Figure 10. *The Print Preview screen.*

Model Extents box. I set print quality to Standard, and I ignore the Use High Accuracy HLR box; leave it unchecked.

Click OK to display the print preview, as shown in Figure 10. Scroll through the document or the selected scenes you have chosen to print. You can choose to see one or two pages at a time. If you like what you see, then click on the Print button. The Print dialog box will return; click OK to finish the job. If you aren't satisfied with the print preview, then click the Close button to back out of the printing process and make your adjustments.

That's all there is to do simple printing on Windows computers.

Print Setup for Macintosh

Click on File in the Menu Bar and select Page Setup, as shown in Figure 11. This opens a new screen, as shown in Figure 12. Use this screen to set up the printing for landscape orientation.

After completing the page setup, click on File in the Menu Bar again. This time, choose Print from the menu, which opens the Print screen, as shown in Figure 13. Click on the Preview button. This opens the box shown in Figure 14. Check the Fit View to Page box, then click OK. Scroll through the previewed pages and click the Print button if you're satisfied with the output. If not, you can back out of Preview and make adjustments to the scene or the page settings.

How to Print Full-Size Templates

There are two key things to remember about making templates in SketchUp.

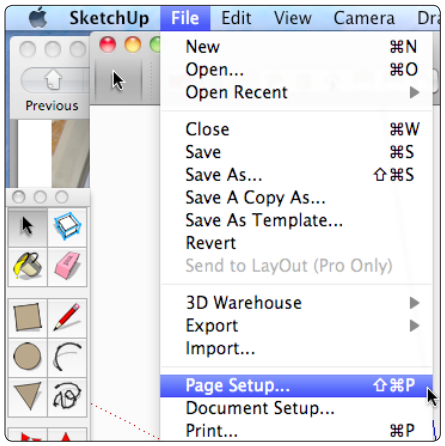


Figure 11. *The Print Setup dialog box on the Mac.*

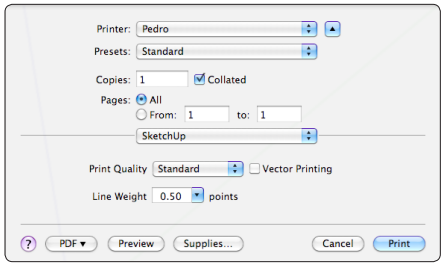


Figure 13. *One button at the bottom of the print screen lets you select Print Preview.*

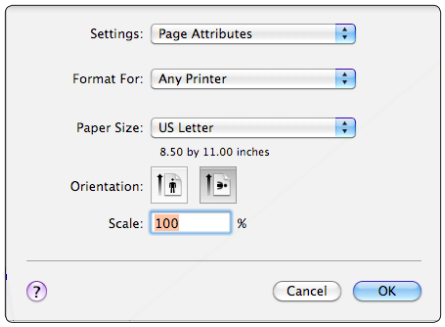


Figure 12. *The Page Setup dialog box on the Mac, where you select the printer and landscape orientation.*

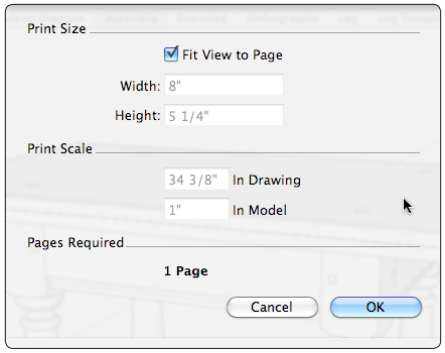


Figure 14. *The Print Preview setup page on the Mac.*

First, the Scene or the view in SketchUp must have the Camera set to Parallel Projection. You cannot print a full-size template if the Camera is set to Perspective mode.

Second, the view must be set to one of the standard views, such as Top, Front, Right, or Left. When you set a standard view, avoid using the Orbit Tool on that view, which negates the standard view setting. You can use the Pan Tool but not the Orbit Tool.

I'll use the Connecticut stool as an example to show how to print a full-size template.

Click on the Leg Template Scene; this opens the view shown in Figure 15. It's in Parallel Projection and Front View.

If the printer can handle only 8½-in. by 11-in. paper, the template will have to be printed on multiple tiled pages. The trick is to arrange the view of the component to minimize the number of sheets needed. This is my preferred method.

In the upper right hand corner of a Windows computer are the three buttons to

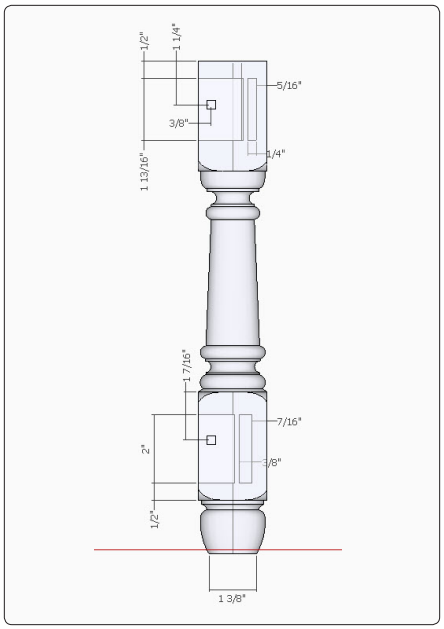


Figure 15. *Open the scene you want to print as a full-size template. Be sure it's in Parallel Projection and one of the standard views.*

Figure 16. *These buttons control the size of the active screen.*

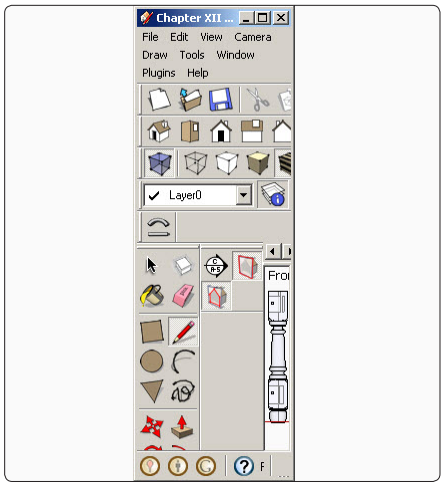


Figure 17. *Use the Restore Down button, and adjust the size of the window to minimize white space around the component.*

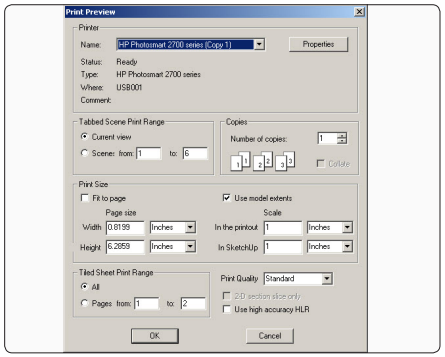


Figure 18. *The Print Preview dialog box.*

Minimize, Restore Down, and Close the active screen. (Similar buttons are in the upper-left-hand corner on Macs.) Figure 16 shows the buttons. Click on the middle button, for Restore Down, then adjust the size of the window to eliminate as much white space as possible (Figure 17).

Click on File in the Menu Bar and choose Print Preview from the drop-down menu. That opens a dialog box like the one shown in Figure 18. Be sure that Fit to Page is not checked, that Use Model Extents is checked, and that the Scale is set to 1 to 1. I set the page orientation to Portrait, which is better for the thin, tall leg component. The Print Range shows only two pages, which is what you want to see. Click OK.

Templates Using SketchUp Pro and Layout

With SketchUp Pro (the paid version) and Layout, you have the best options for making full-size templates. You can bundle many templates on one page, print on large sheets, and export the scenes as Adobe PDF files.

I use Pro and Layout exclusively when I package templates for my students or other customers. By printing on a 24-in. by 36-in. sheet, for instance, I can usually arrange all the templates on one sheet as a PDF file; it's a handy and ubiquitous format. You can print the PDF files with Adobe Acrobat on a small home printer and patch the pages together. Or you can send the file to a local print shop to output on a large-format printer. That eliminates the tedium of patching small sheets together.

The print setup work is the same as with the free version of SketchUp. Create a scene for the template, set up the Standard View, and set Camera to Parallel Projection (Figure A).

Note that I've added registration marks. They aren't required, but they help if you have to patch small sheets together. In Adobe Acrobat (the paid version), you can tile multiple pages with Cutmarks.

Insert the SketchUp file into Layout and select the Leg Template scene to open in a page of Layout (Figure B). I've rotated the view in Layout to take advantage of the Landscape orientation of the paper.

Right-click on the leg template and select Scale. Then choose Full scale 1:1 in the pop-up menu. You'll probably need to use the Pan Tool to get the top of the leg fully in view.

Create three more pages in Layout on which you arrange the remaining three segments of the leg.

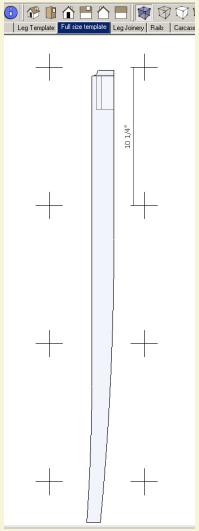


Figure A. *The Print Setup dialog box in Layout.*

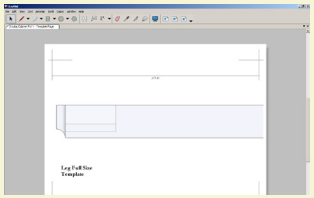


Figure B. *The leg component placed into Layout and scaled to be full size.*

Click on the Print button, then click OK in the Print dialog box.

This method has one drawback: It jumbles the Toolbar positions at the top of the SketchUp screen. So I must return the Toolbars to their original single-line location whenever I have to use this technique to print a template.

If desired, you can create small registration marks in the corners of the SketchUp file to help align the multiple pages of the template.

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