CONSTRUCTING WOODEN TOYS

Plans and instructions for making 15 toys,
including techniques and jigs for machining small parts safely

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All proceeds are used by the SDFWA to support the toy donation program and other Association activities. For comments, suggestions, or questions about this book, please contact us at ToyBook@SDFWA.org.

In memory of

Helen and Charlie Bierman

Dedicated to Charlie Bierman

We worked with Charlie Bierman for 15 years, sharing many days together building wooden toys for donation through the San Diego Fine Woodworkers Association Toy Program or preparing materials for others to use in toy making.

Charlie was an innovator, perfectionist, and an extraordinary teacher. He was constantly designing new toys and finding better and safer ways to build them. For 20 years he was the leader of a toy building workshop of 15 members that still meets once a week and produces over 500 toys a year for donation.

He organized and instructed a four weekend course at Palomar Community College for many years, and he coordinated the work of other toy building workshops in San Diego County. To our knowledge, no toy left the Toy Program for donation without his stamp of approval for operation and safety.

Some years ago Charlie put together a pamphlet of instructions on the methods that he and others had developed to safely machine small toy parts and to mass produce these parts so that a number of duplicates of a toy could be produced efficiently. This pamphlet was used many times in workshops he gave over the years.

In 2016 he asked us to help him convert the material in this pamphlet into a full-length book, along with step-by-step instructions for building 15 of the most popular wooden toys made by the Toy Program. We met regularly to hash out ideas, review copy, and make decisions regarding content.

Charlie died in August 2017. He was working on this project up to the day he died. This book will serve as one of his many legacies, and we hope the reader enjoys using it as much as we enjoyed working with Charlie.

Steve Naiman
Charlie Pinkus
June, 2018

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Preface

The Toy Program of the San Diego Fine Woodworkers Association (SDFWA) takes pride in making quality wooden toys for donation to children throughout San Diego County. Since the inception of the Program about 25 years ago, the Association has given away approximately 35,000 toys to over 50 non-profit organizations that serve children, such as day care centers, health clinics, and pre-schools.

The purpose of this book is two-fold: first, to provide plans and step-by-step instructions for making fifteen of the Program's most popular toys; second, to share a number of tips, techniques, and jigs unique to toy making that members of the Toy Program have found to be of great use for safely machining small toy parts.

The SDFWA toy workshops make 20 to 50 toys for donation at the same time. Some of the jigs described in this book were designed to make duplicates of toy parts that are interchangeable.

We hope that the information in this book will help you find pleasure in making wooden toys for your children, grandchildren, and friends, as well as for donation.

More information about the SDFWA can be found at: www.sdfwa.org.

Acknowledgements

We are indebted to a number of people who helped with various aspects of this book. This work would not have been possible without the excellent drawings produced by Bill White. In addition, we thank Lynn Rybarczyk and Andy Patterson for taking photographs of the toys included in the book and Sejal Pinkus for designing the covers. We are very grateful to Susan Davis for her thorough editing and suggestions, and Mike Davis for technical support.

Incorporated in this book are the ideas, knowledge and skills of many members of the SDFWA Toy Program. In particular, we thank Bob Dodds, Ed Gladney, Dan McNaughton, and Mark Tally who contributed drafts of several of the chapters. We also appreciate the reviews and comments on this work by Jeff Bratt, Roger Solheid, Dale Stauffer, and the support of the Board of Directors of SDFWA. Finally, we thank Augie and Shikari – our toy testers.

1. Safe Toys and Woodworking Safety

Introduction

This book is divided into two parts. If you are like the authors, you will want to get started constructing toys as soon as possible. Therefore, in Part I (Chapters 2 – 17) we include plans and instructions for making fifteen toys designed to amuse and educate.

Each of Chapters 3 though 17 is devoted to a different toy, and each of these chapters is self-contained. Therefore, it is possible to skip around and work on only the toys you are most interested in making.

Chapter 2, the first chapter of Part I, gives some important instructions and tables used throughout the book. It is suggested that you skim through this chapter to become familiar with the things that will be referred to often in Chapters 3 – 17, before starting to construct toys.

Part II (Chapters 18 – 22) is on toy making techniques and jigs. It is divided into chapters on each aspect of toy making, from shaping the body of a toy to assembly. These chapters include tips that apply to all the toys described in Part I, from machining small parts safely to examples of the jigs that have enabled the SDFWA Toy Program members to efficiently make 20 to 50 toys at a time for donation.

The remainder of this chapter provides some very important information on safety for you and for the child playing with toys, along with observations on how the design of toys influences the ways that children play with them.

Safety

Personal Safety

A number of the woodworking procedures presented in this book require cutting, drilling, and routing operations on small parts. It is essential that these parts are held firmly, either in a vise or with a clamp, in order to safely complete operations on them.[1]

It is also essential that fingers are kept as far away as possible from tools. This can be difficult in making wooden toys, because toys are very small projects as woodworking projects go.

[1] **Disclaimer**: Neither the authors nor the SDFWA (its directors and officers) assume responsibility for any injuries suffered or damages or losses incurred arising from the use of the information contained in Constructing Wooden Toys.

Remember to:

- Take your time - do not rush a procedure.
- Check and double check measurements.
- Avoid shortcuts – look for the safe way to complete every operation.
- Understand plans and instructions before beginning work on a toy.

Be constantly aware of potential dangers associated with using hand and power tools. Always be familiar with the safe procedures for using your tools, and never override safety measures out of laziness, fatigue, anger, impatience, or the desire for speed.

If you are not comfortable with a procedure or instruction that you see in this book or elsewhere, find another way to do it. If it seems dangerous to you, it probably is.

Finally, if you have not already taken a woodworking course during which you have passed a safety test, we strongly advise you do so before embarking on the projects contained in this book.

Woodworking can be very enjoyable, but it can also be dangerous. Don't let an accident ruin your enjoyment.

Safety of Toys

To insure that the wooden toys you make are safe for children to use, ask yourself the following questions:

1. Does the toy have smooth edges and corners and no rough surfaces?
2. Are all parts securely attached?
3. If it is a toy that has wheels, such as a car, does it roll freely when pushed on a hard surface?
4. If the toy has mechanical parts, does it work properly when pushed across a hard surface?
5. Do all loose, small parts satisfy the United States Consumer Products Safety Commission's regulations for small parts for toys?

If you cannot say "yes" to all of these questions, repair the toy before letting a child play with it.

Small Parts Regulation

The purpose of this regulation is to prevent deaths and injuries to children under three from choking on, inhaling or swallowing small objects.

Figure 1-1 shows the anti-swallow test device developed by the Consumer Product Safety Commission.

Questionable parts are placed in the cavity of the test device. If a small part fits completely into the cylinder, and the toy or product from which it came is intended for use by children under three, the toy or product is banned because it presents a choking hazard.

If the part protrudes above the cavity, it is considered safe. If you plan to design wooden toys, it would be useful to have a copy of this test device. It can be purchased[2] or made.

Following are the steps to make the device (see Figure 1-2 for the plan):

1. Start with a block of wood 2" wide, 3" long, and 2" deep.

2. Drill a 1 ¼" hole centered on one of the 2" x 2" ends through the entire 3" block.

3. Take a 1 ¼" dowel and trim the end at a 45 degree angle.

4. From the end that was cut at 45 degrees, cut off 2" from the longest side of the 45 degree angle. You should now have a piece of 1 ¼" dowel with one end cut at 45 degrees. The short side should measure ¾"; the long side should be 2".

5. Test that the dowel slides into the 1 ¼" hole cut into the 2" x 2" x 3" block of wood so that the flat end is square with the bottom of the cavity as shown in Figure 1-2. It might be necessary to sand the dowel to get it to fit.

6. Remove the dowel, put glue around the lower inside of the cavity, and glue the dowel in place.

7. The test device created should have the same cavity as the device shown in Figure 1-1.

Figure 1-1. Anti-swallow Test Device

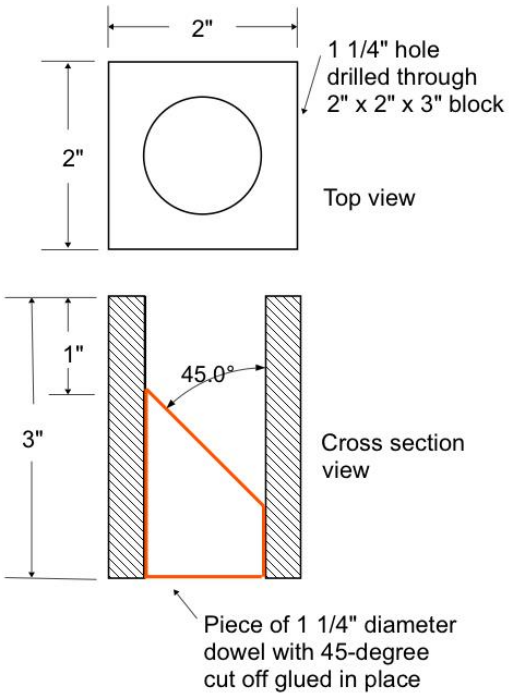


Figure 1-2. Plan for Making Anti-swallow Device

[2] Anti-swallow test devices can be found by searching the internet, for example "Safety 1st Small Objects Tester". The cost is approximately $10.

How Children Play with Toys

There are many different types of toys, and children will find many different ways to play with any given toy. It is, however, important to distinguish between some common types of toys in terms of how children might play with them.

One basic distinction is between toys that are propelled, such as a toy car pushed along a floor, and toys whose pieces are manipulated, such as a puzzle. Furthermore, toys are propelled in one of three ways: either by a push stick, a pull string, or by hand.

The toy building chapters that follow include four push toys and four pull toys, including two toys that can be made as either a push or pull toy. In addition, there are four toys designed to be propelled by hand, and the remaining three toys are manipulated but not propelled, for example, the doll bed/cradle (Chapter 7).

The importance of the distinction between push and pull toys follows. .

Push Stick Toys

Push toys are considered better than pull toys for children learning to walk. This is because children want to watch the motion of the toy. If the toy needs to be pulled, the child will have to walk backward to see it. Obviously this can lead to falls and bumps that can be mostly avoided by having the child push the toy.

In addition to allowing the child to watch the toy as he/she walks forward, the push stick also provides greater control over the movement of the toy and teaches directional control.

The push stick is a sub-assembly that is used on four to six of the toys described in this book. Rather than repeat the instructions for each toy, the steps for making a push stick and its grip are given in Chapter 2.

Pull String Toys

There are some toys that can be built with either a push stick or a pull string. The duck (Chapter 6) is an example. However, there are some toys that cannot make use of a push stick, for example, the honey bee (Chapter 8). To propel such toys, a child must either propel it by hand or use a pull string.

A toy with a pull string should only be used by a child who is comfortable walking backward because it is natural that the child will want to look at the toy as it is being pulled.

Since several toys in this book use a pull string, suggestions for making and attaching a pull string are given in Chapter 2.

Part I. Toys

2. Getting Started

This chapter includes information that is used in most of the toy chapters. It is often referred to by the instructions in those chapters, thus avoiding repetition. It is suggested that you skim through this chapter to become familiar with the topics covered here, because you will likely need to refer to it later.

The tools and materials you will need to make the toys in Chapters 3 through 17 are descibed here. Also included is important information about the dimensions for some commonly used toy parts.

At the end of the chapter are instructions for making subassemblies for push sticks and pull strings used by a number of the toys, and critical information on glued parts and rotational parts.

How to Proceed

In planning this book, the authors had originally intended the toy chapters to be used by beginners as well as experienced woodworkers, and that a limited number of power tools would be required.

It soon became apparent that power tools were going to be essential in order to build many of the toys. However, for the reader with few if any power tools, we suggest beginning by making small cars and trucks (Chapter 3), the weedwacker push toy (Chapter 4), the circle animal puzzle (Chapter 5), or the doll bed/cradle (Chapter 7).

It has already been noted that once you become familiar with the content in this chapter, you can skip around among the 15 toy chapters (3 through 17) to work on only the toys you are most interested in making.

Each of the toy chapters is self-contained. However, in order to make them self-contained we have needed to provide some repetition or reminders in these chapters. To limit the repetition, we make liberal use of boxes throughout the book that refer the reader to more information about an instruction or topic. The boxes are color coded as follows:

Red Box

A warning about an important instruction
or a reference to a sub-assembly described elsewhere.

Green Box

A reference to more information about a topic,
including how to make jigs to safely machine small parts.

Tools

We all have different woodworking experiences and skills, not to mention different tools. It is assumed, however, that the reader has basic skill and knowledge of woodworking practices and tools.

Although there are occasional exceptions, to build each toy requires the following general steps:

- Create rectangular blocks of wood (called "blanks") out of which the main part, the body of the toy, and other parts are made.
- Transfer the design of the body and other parts to the blanks. Templates for all the major parts are given in each chapter.
- Drill holes while the blanks are still rectangular.
- Rough cut-out the parts from the blanks.
- Sand the body and other parts to the outline on the blank.
- Round over edges and do finish sanding.
- Seal the parts, apply a top coat of finish, and assemble the toy.

Depending on the tools you have available there are a variety of ways to accomplish these steps.

Below are lists of tools that can be used for the operations described above. In general, for each operation the list is arranged from the most preferred tool to the least preferred. Using the least perferred tools can be a challenge for making most of the toys, but this will depend on your skill and patience.

Cutting Tools Needed

You will generally need one tool from each of the following groups to perform the given operation:

Cutting straight edges
- Table saw
- Chop (miter) saw
- Circular saw
- Hand saw

Cutting curves
- Bandsaw
- Scroll saw
- Jig (saber) saw
- Coping saw

Drilling holes
- Drill press
- Hand power drill
- Hand drill

Rounding over edges
- Stationary router (that is, a router attached to a router table)
- Wood rasp
- Block plane
- Sanding block

Sanding
- Oscillating spindle sander
- Stationary belt sander
- Stationary disk sander
- Sanding drums
- Sanding block

Other Tools and Supplies

Following are some general tools and supplies that are needed for many of the toy construction projects in this book, along with some measuring instruments that would be useful to have available.

Other tools

- Clamps
- Phillips head screw driver
- Drill bits (see section on Dimensions)
- Center punch or nail
- Roundover bits (⅛" to ¼")

Supplies

- De-waxed shellac
- Water-based polyurethane
- Wood glue
- Wood molding glue
- Sand paper (80 – 150 grit)
- Foam sanding pad (fine grit)

Measuring instruments

- Metal rulers (6 inches and longer)
- Tape measure
- Metal square
- Caliper (to measure diameters)
- Protractor
- Compass

Tools Needed for Each Toy

Specific tools required to make each toy are generally not indicated by the step-by-step instructions in Chapters 3 - 17. Rather, it is up to the reader to select the best tool at your disposal. Any tools unique to building a given toy will be referred to as "special tools" in each chapter, for example, the size and type of drill bits needed.

Materials

Hardwood is generally preferred for the body of a toy. However, in many cases a toy's body needs to be made out of wood that is 1 ½ to 2 inches thick. This thickness of hardwood is generaly not found at a hardware or do-it-yourself lumber store.

It might be possible to purchase short pieces of thick hardwood such as oak, maple, birch, cherry, walnut, and mahogany, to name a few, from your local lumber mill or woodworkers' store. Short pieces of hardwood left over from furniture making projects often provide enough wood for making a toy.

We generally avoid softwoods, but some that are of good quality are acceptable. However, fir is not recommended because it contains resin that can clog sandpaper and tools, and construction lumber should be avoided since it presents a challenge in accurately locating and drilling holes into it.

A good alternative to purchasing thick or wide pieces of hardwood is to glue together more accessible ¾" thick pieces to form the wood blanks needed for a toy.

Making Thicker and Wider Toy Blanks

See Chapter 18, pp. 151-2

Often it is necessary to purchase parts like small wheels, axle pegs and wood buttons. Local craft stores might stock these parts, but the variety will be limited. It is best to purchase these parts through suppliers that can be found on the internet, and these parts are generally reasonably priced. The Appendix lists several suppliers of these parts.

Large wheels are used in a number of the toys in Part I. These can be very expensive to purchase, so methods for making them are described in Part II. These methods can also be used to make small wheels, if that is preferred to purchasing them.

You will find the dowels, washers, screws, and eyelets that are used to make some toys at your local hardware store.

Dimensions

THIS IS VERY IMPORTANT! At the beginning of the instructions for making each toy are two tables listing the parts needed. The first shows the wood parts that need to be machined – called the "Cut List."[3] Most of these parts will be cut from blanks of wood. Some will be cut from purchased parts. The second table gives the list of "Other Parts" usually purchased parts requiring little or no modification.

Both tables give the dimensions of the part or wood blanks for the toy being constructed. However, it is **IMPORTANT** to note that in many cases the main part of the toy, the "body," requires a thickness of wood that can vary.

Often a range of thicknesses is given, allowing some flexibility in using the wood that is available. In such cases the toy can be made regardless of the exact thickness of the body.

This flexibility in thickness for the wood chosen for the body means that the dimensions of other parts used to construct this toy might need to be adjusted in length because they depend on the thickness of the body. For example, this would be the case for the length of an axle that needs to pass through the body of a toy car.

Therefore, when dowels are listed to be used for the axle of a toy, the length given is long enough to be used with whatever thickness is chosen for the body and the phrase "cut-to-fit" will follow the item.

After deciding on the thickness of the toy's body, it is important to check the dimensions of all the other parts to be certain they will work with the chosen thickness of the body. It might be necessary to adjust the dimensions of these parts.

[3] "Machined" refers to cutting out, rounding over edges, sanding, and drilling operations.

Cut Lists and Dimensions

Don't be concerned that the dimensions for some parts shown in the Cut List are a bit greater than the dimensions given on a diagram for the part.

This is because the dimensions for a part that need to be shaped from a blank will be given oversize to help in transferring the template for the part to the blank and in cutting out the shape.

This usually applies to the body of the toy, but can also apply to some of the parts to be attached to the body.

Templates

In each chapter there are templates for many of the parts that need to be cut from blanks. The templates are used to draw an outline of the part on the blank. Use tracing paper or a photo copy of the template to do this, being certain to not only draw the outline but also mark any holes that need to be drilled into the part.

Drill Bits and Hole Sizes for Glue Joints and Rotating Axles

Some of the small toy parts used for the toys in Part I are purchased, for example dowel rods, axle pegs, and wooden buttons. It is essential to have the correct size drill bit for creating the holes in which these parts will fit.

In some cases the parts will be glued into the hole; in other cases the part will need to move freely, for example a wheel axle.

Unfortunately, some of the drill bits needed to create the holes for these parts are not in the group of six to 12 drill bits commonly sold as a set. Although individual drill bits of almost any size can be purchased at a store that specializes in woodworking tools[4], if you plan to make a number of toys, an investment in a large set of drill bits containing fractional sizes, letter sizes, and decimal sizes is very useful.[5] See the Appendix for a complete list of the decimal equivalents of a wide range of drills.

A large selection of drill bit sizes will provide a wider option for making a good glue joint with dowels, axle pegs, and wooden buttons.

The table on the next page shows the commonly used toy parts and the normal drill bit sizes to create a glue joint or to create a hole for a rotating axle. Use this table with caution. It is best to check the size of holes in a piece of scrap wood, especially for holes that are to make a glue joint.

[4] For example, Rockler Woodworking and Hardware.

[5] Harbor Freight sells a set of 115 bits that will cover all needs. Look for it on sale!

Part	Normal drill bit size for glue joint	Normal drill bit size for a rotating axle	See technical details below
7/32" axle peg	15/64"	1/4"	a
11/32" axle peg	11/32"	3/8"	b
1/4" dowel	1/4"	9/32"	c
3/8" dowel	3/8"	13/32"	c
1/2" dowel	1/2"		c
1/4 " wood button	17/64"		d
5/16" wood button	21/64"		d
3/8" wood button	25/64"		d

Notes:

a. This axle peg is designed so that a wheel with a 1/4" center hole will rotate on it. In lists of toy parts in this book the size of this axle peg is given as 7/32", the diameter of its tenon. An axle peg with a 15/64" diameter tenon will also work.

b. This axle peg is designed so that a wheel with a 3/8" center hole will rotate on it. In lists of toy parts in this book the size of this axle peg is give as 11/32", the diameter of its tenon. An axle peg with a 5/16" diameter tenon will also work.

c. See box on the next page regarding proper glue joints for dowels.

d. These are "mushroom" buttons. The part dimension given is the diameter of the hole they are designed to fill. The normal drill bit size for a glue joint is slightly larger than this dimension because the tenons are tapered.

Holes for Rotating Axles

Warning – Rotating Parts

Holes for rotating parts need to have between 1/32" and 1/16" clearance to enable the parts to rotate freely. After drilling the 9/32" hole for a 1/4" dowel that will serve as a rotating axle, check that the dowel rotates freely in the hole. Since the diameter of dowels tend to vary slightly from the dimension advertised, it might be necessary to re-drill the hole with a slightly larger drill bit if the fit is tight. The same warning applies to holes for 3/8" axles.

Applying some paraffin to the center of a dowel will help the wheels spin freely. But it is critical to keep the wax away from the ends of the dowel that will be glued into a wheel or another part.

Glue Joints for Dowels, Axle Pegs and Wood Buttons

Warning – Glue Joints

We have found that purchased dowels, wood buttons, and axle pegs might have diameters that vary from their advertised dimensions. This is true not only from parts purchased from different manufacturers but also from the same manufacturer.

For example, it would not be unusual for a ¼" (0.250") dowel purchased for the axle of a toy to actually have a diameter as small as 0.240" or as large as 0.255" Since this dowel will need to form a solid glue joint with the ¼" hole in a wheel, the fit should be tested in the wheel or by using a piece of scrap wood before gluing.

Therefore, before gluing a dowel, axle peg, or wood button into a hole, find out if it is necessary to make adjustments for too loose or too tight a fit.

The Test: A dowel (axle peg, or wood button) should fit easily into the hole in which it is to be glued without applying force. It should fit snuggly and should not fall out when the object in which it is placed is turned over. Test the fit in the center hole of purchased wheels, and test the fit by drilling a hole in a piece of scrap wood before drilling a hole in a toy part.

Correction for a Loose Fit: In gluing a dowel into the center hole of a wheel, if the dowel is loose and a **small amount** undersized, a thicker glue[6] should be used. If it is a **very loose** fit, try to find a larger diameter dowel. When gluing a dowel, axle peg, or wood button into a part for a toy and the fit is loose when tested in a piece of scrap wood, either use thicker glue or use a smaller drill bit to make the hole in the part.

Correction for a Tight Fit: On the other hand, if the dowel, axle peg, or wood button is oversized and will not fit into the hole unless forced, a slightly larger drill bit will need to be used to re-drill the hole or to ream it out (see Chapter 19, p. 169), or the end of the part that is to fit into the hole will need to be sanded until a good fit is achieved.

Another option: An investment in a few "lettered" size drill bits is a great help in achieving good fits for dowels, axle pegs, and buttons. In the case of ¼" (0.250") holes, the "C" (0.242"), "D" (0.246"), "F" (0.257") and "G" (0.261") lettered drill bits are very useful. For ⅜" (0.375") holes, the "T" (0.358"), "U" (0.368"), "V" (0.377"), and "W" (0.386") lettered drill bits are very useful.

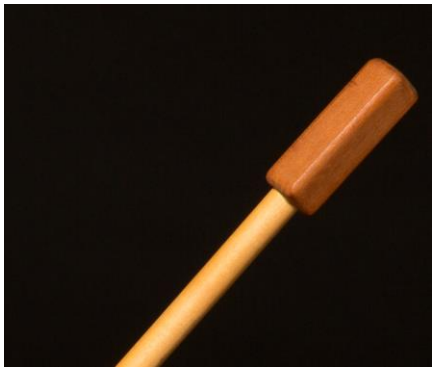
[6] For example, Titebond Molding and Trim Glue can be used to create a glue joint in a slightly oversized hole.

Sub-assemblies

Push Stick and Grip (Figure 2-1)

1. Cut the push stick from a ½" diameter dowel. Most hardware stores stock these dowels and they are generally 3 feet long. The length should be cut to suit the child that will be using the toy. Without specific knowledge about the user, a common length is 17 ⅞" - enabling two push sticks from one dowel.
2. The design of the handle grip is shown in Figure 2-2. Although the grip is optional, it might make it easier for a child to hold onto the stick when pushing the toy. Cut a piece of hardwood ¾" by ¾" by 2 ½" long. Round over all edges of the grip to a ⅛" radius, then sand the entire grip and the dowel.
3. To safely drill the ½" hole ¾" deep into the end of the handle grip, clamp the grip securely in a vice or to fence of a drill press.
4. Test the fit of the dowel in the hole drilled at the end of the grip to determine if it will make a good the glue joint with the grip. If the fit is tight, sand ¾" of the end of the dowel until a good fit is achieved. See warning on glue joints (p. 19).

Figure 2-1. Push Stick with Handle Grip Attached



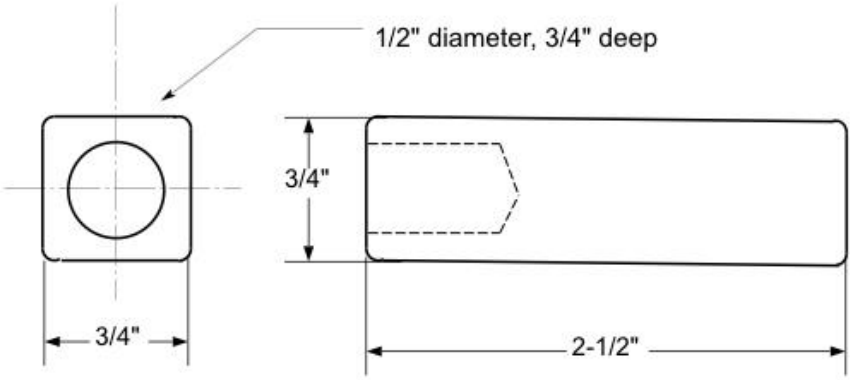


Figure 2-2. Handle Grip

Making a Pull String

1. Braided nylon works best for pull strings. It comes in bright colors.
2. Cut the string with a hot string cutter, or if such a cutter is not available, melt each end of the string with a match or lighter.
3. Tie a loop at one end for pulling. Put a drop of glue on all knots or they will become loose (see Figure 2-3).
4. If it is desired to atach a ball or piece of dowel to the end of the string, be sure it will pass the anti-swallow test using the device shown in Figure 1-1.
5. The string length should be between 18" and 30", depending on the toy configuration and the age of the child using the toy. Testing with a child is best.

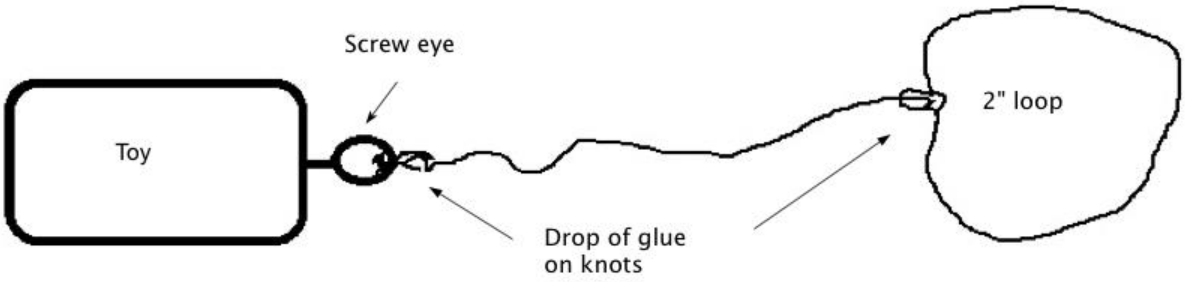


Figure 2-3. Pull String

On to Toy Building

At the start of each of the toy chapters you will find: the list of materials needed to make the toy, plans including all dimensions, a list of special tools required for that toy, and step-by-step instructions for machining and finishing the parts and assembling the toy. When needed, a template (actual-size drawing) is provided for tracing the outline of the parts on wood blanks.

In most cases several different types of tools could be used to fashion a given part of a toy. For example, in cutting out the body of a toy whose shape is curved, we generally prefer making a rough cut with a band saw, then smoothing out the edges with a drum or oscillating spindle sander. But if you don't have access to a band saw, a scroll or jigsaw will suffice, or perhaps even a coping saw, and you can always sand by hand.

The list of tools you could use for a given operation, shown earlier in this chapter, are ordered by the generally most preferred tool to the least preferred. There are exceptions, however, and they will be noted in the individual toy chapters.

Finally, it is recommended that you review all the instructions for building a given toy to determine if the tools at your disposal will enable you to accomplish all the cutting operations required.

Part II. Jigs and Techniques

18. Shaping Parts

Most of the toys described in Section I of this book have a main part, called the "body" of the toy. If the toy has moving parts, they are uusally attached to the body. Making the body or any other part of the toy starts with a square or rectangular block of wood – the wood blank.

If a template is going to be used in cutting out a part, the dimensions of the wood blank in the Cut List will be slightly greater than the part to allow for transfering the design from the template to the blank and cutting out the part.

Forming the Wood Blank

The first challenge in beginning a toy building project is to obtain the size of wood needed for the parts.

Although it might be possible to obtain a rectangular block of wood with the length required, it might not be possible to find the width or thickness needed. Many of the toys described in Section I required parts to be made out of wood that is thicker than ¾" – the standard thickness of most readily available lumber.

Unless you have made furniture requiring wood that is 1" to 2 ½" thick and have scraps left over, it is unlikely you will have the lumber out of which the wood blank for the body and other toy parts can be obtained. In addition to the thickness, finding the proper width can also be a challenge.

There is a simple solution to these problems - gluing together two or more pieces of wood to form the thickness and/or width needed.

Wide Blanks

Gluing two or more pieces of wood together to form a wider block of wood is a fairly easy process. In addition to the wood, the supplies and tools needed include wood glue and clamps.

The process is known as edge gluing, that is, gluing the individual pieces of wood edge-to-edge. If you have never done this before, we suggest searching the internet for "edge gluing" videos that will demonstrate the procedure.[38]

Here is a brief summary of edge gluing. Critical to the process is making certain the edges are perfectly straight and square to each other. Then apply glue to both edges and clamp the pieces together every 12".

Let the glue set for about 30 minutes, then scrape off any glue that has squeesed out from the edges. Clean up the surfaces by sanding or passing through a planer. Repeat with a third piece of wood, if necessary.

[38] See for example, "3 steps to great glue ups: edge joints" produced by the FineWoodworking magazine.

Thick Blanks

Creating a thick blank from two or more pieces of wood is known as face gluing, that is, gluing together the faces of two or more pieces. The procedure is similar to edge gluing. Searching the internet for "face gluing" will provide videos that offer tips on this process.

Steps for Making the Body of a Toy

The normal steps for making the body of a wooden toy are:

1. Work out the machining and sanding sequence.

2. Start with a square or rectangular wood blank. Sand all surfaces to remove saw and/or milling marks. If the wood blank has been created by edge or face gluing together two or more pieces of wood, it is necessary to check the blank to see that all surfaces and edges are clear of glue and are square. Sand with the direction of the grain.

The Blank

3. Do any accessible straight saw cuts.

4. If the body has a curved shape, transfer the shape of the body from a template to the block of wood, creating an outline on the wood. Mark hole locations using the plan or template.

Outline of Part with Hole Locations

5. Drill holes in the body while the blank is still rectangular. The square edge of the blank makes it easier to clamp the blank against the fence of a drill press in order to align the holes. This is especially important if making duplicate copies of the toy.

Holes Drilled in Blank

6. Cut the contour of the body to within $^{1}/_{32}$" to $^{1}/_{16}$" of the outline. (There are cases where contouring will precede some drilling and straight cuts.)

Body Cut from Blank

7. Sand the body contour to the outline on the block of wood.

8. Do any necessary round over of edges. (Sometimes rounding over edges, if done on a router, will need to be completed before drilling some of the holes. Holes in the edge can prevent the round over bit bearing from running smoothly along an edge.)

Router Safety

DO NOT USE a router to round over edges of toy parts **UNLESS** the router is station-ary, that is, attached to a router table. See p. 158.

9. Sand out any saw or milling marks or burn marks from cuts and rounding over, and then sand all surfaces and edges.

   View the body in strong light. If surfaces are not well prepared, a clear finish will em-phasize defects. If necessary, sand some more.

Band Sawing

Bandsaw Safety

This is not intended to cover all the safety aspects in using the band saw, but just a few key issues in cutting parts for toys:

1. Always keep the upper blade guide about ¼" above the work piece. This not only reduces the chance of getting your fingers near the blade teeth, but also provides better blade support for truer, smoother cuts.

2. When cutting small parts, keep your fingers out of the danger zone – the area 1 ¼" from the blade teeth or the area of the table insert.

3. Use the correct blade for the job: ½" or wider hook blades for re-sawing; standard and skip tooth blades for scrolling. Match the blade width to the smallest radius required.

4. When cutting dowels, grip them securely to prevent rotation.

5. While the blade is moving, do not back up the wood on long cuts or curves. Shut off the bandsaw before backing up.

Remember: be alert and safety conscious at all times.

Key Bandsaw Set-up Procedures and Adjustment

1. Guide blocks for the blade must be smooth, true, flat and properly adjusted. Regularly remove and re-grind them. Even metal guides become "grooved," allowing the blade to move around no matter how well adjusted.

2. Follow the band saw manual for the correct guide block adjustment gap. It is usually 0.003 – 0.005".

3. Make sure the blade has **not** been "pushed" out of its true path with the band saw blade wheels.

4. When all adjustments have been made, check that the blade is square to the band saw table.

5. Check that there is proper tension on the blade. One way to do this is to raise the upper guide 6" with the power off. Then push the blade sideways with your finger. The blade should not deflect more than ¼" if under proper tension.[39]

Making Wheels

Wheels up to 2" in diameter can be purchased at economical prices. This is not true for the larger wheels needed on some of the toys described in Part I. If only a few large wheels are needed, it still might pay to purchase them.

Wheels that resemble car or truck tires are best purchased. However, there are ways to make wheels of any size if you have access to a drill press or a band saw. These wheels will have flat surfaces. See, for example, the hippo (Chapter 15) or rolling rattle (Chapter 16).

Chapter 19 describes a simple way to make wheels using a drill press and hole saw.

Following are are two methods to make large wheels using a bandsaw – freehand and using a special purpose jig.

Freehand Method

This method takes considerable practice and patience.

1. Use a compass to draw the wheel on a square blank of wood that is slightly larger than the desired wheel.

2. Drill the center hole, usually either ¼" or ⅜" in diameter.

3. Follow the pattern as closely as possible as you cut out the wheel. It is best to do this with a bandsaw or scroll saw. Try to cut out the wheel to within $^1/_{32}$" to $^1/_{16}$" of the pencil outline on the blank.

4. Sand to the outline. A stationary belt or disk sander works best for this operation, in conjunction with the circle sanding jig described in Chapter 20. If this equipment is not available, sanding can be also be done using a hand sanding block.

5. Round over the edges to a ⅛" or $^3/_{16}$" radius, either by hand or using a router installed in a router table in conjunction with the jig described later in this chapter.

[39] Finewoodworking.com/2012/11/09/

6. Sand all surfaces of the wheel with 150 grit sandpaper.

   An easier way to make wheels on a bandsaw requires the use of a jig. Searching the internet will provide many different examples and demonstrations of bandsaw circle cutting jigs. The simple jig described here is designed for making wheels for toys.

Circle Cutting Jig

Making the Jig

1. Cut a strip of hardwood to fit the miter slot on your bandsaw. It should be snug but also able to easily slide back and forth without binding. Cut the thickness to be less than the depth of the slot.

2. Cut a piece of ¾" plywood approximately the size of your bandsaw table to serve as the base of the jig. It must extend at least 1" to the left of the blade and at least 3" to the right of the miter slot, and it must be long enough to cover the depth of the table.

3. Place the base on the bandsaw table to mark the location of the miter slot, then glue the strip from Step 1 to the bottom of the base, making sure it is square to the front edge of the plywood.

   Reinforce the strip by drilling and countersinking a few ¾" screws or using ¾" brads through the strip and into the base.

4. Make a stop block - a piece of wood approximately ¾" x 1" x 4" long. On the bottom of the base glue this block along the back edge. Reinforce it by drilling and countersinking several drywall screws through it into the base. Figure 18-1 shows the jig to this point.

5. After the glue dries, place the base on your bandsaw table with the guide strip in the miter slot, turn on the bandsaw, and push the base toward the blade until the base stops because the stop block has engaged the front of the bandsaw table.

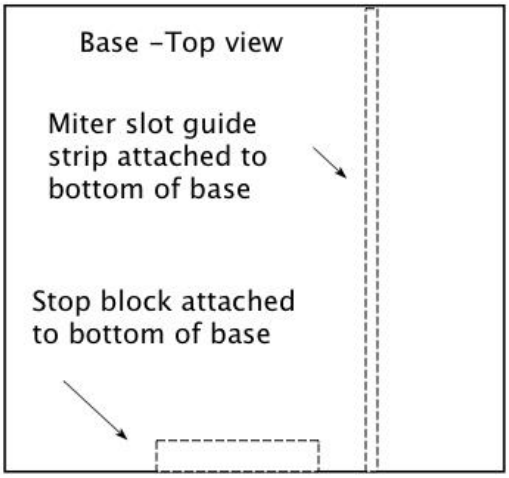


Figure 18-1. Circle Cutting Jig Base

6. After turning off the bandsaw, remove the base and draw a line perpendicular to the cut at the point where the cut ended.

   Measure from the cut along this line the radius of the circle desired. In Figure 18-2, marks have been put at 1 1/16", 2 1/16", and 3 1/16" from the cut. These will be the center holes for making circles that are 2", 4", and 6" in diameter. The 1/16" added to each radius above allows room for sanding. (To sand circles, see the jig described in Chapter 20.)

   Attaching a screw on the face of the stop block will help to fine tune the jig (see Figure 18-2).

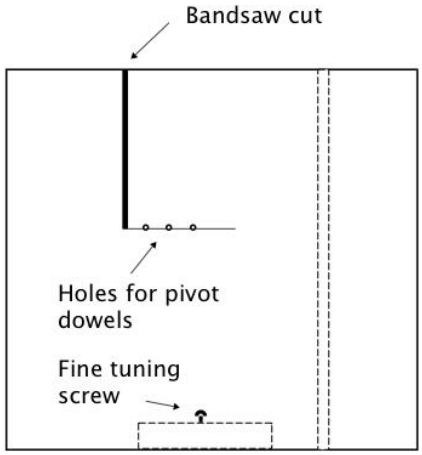


Figure 18-2. Base with Pivot Holes

7. Use a punch to indent the marks made in step 6, then drill a ¼" or ⅜" hole, depending on the size of the center hole of the circle to be cut.

8. To continue the instructions for making and using the jig, it will now be assumed that a 2" diameter wheel with a ¼" diameter center hole is to be made. At the 1 $^{1}/_{16}$" mark from the saw cut, drill a ¼" hole into but not entirely through the base of the jig.

9. Cut a ¼" diameter dowel about 1" long to serve as a pivot dowel. Insert this dowel into the ¼" hole drilled in the base of the jig. See Figure 18-3.

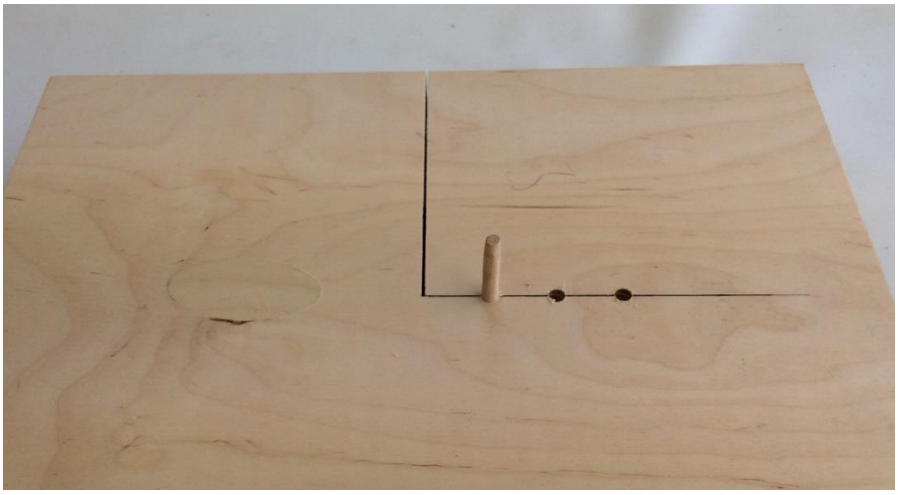


Figure 18-3. Pivot Dowel Set to Make a 2" Diameter Wheel

Using the Jig

1. Prepare a blank of wood out of which a 2" diameter wheel with a ¼" center hole will be cut. The blank should be a rectangle or square piece of wood with its shortest side at least 2 ¼" long. It should be the thickness of the desired wheel.

2. Locate the center of the blank and at that point drill a ¼" through hole.

3. Press the blank on the top of the pivot dowel and put the jig on the bandsaw table with the guide strip engaged in the miter slot. See Figure 18-4.

4. Turn on the bandsaw and push the jig forward while holding the blank on top of the pivot dowel. The jig will stop moving forward when the stop block comes up against the front of the bandsaw table. See Figure 18-5.

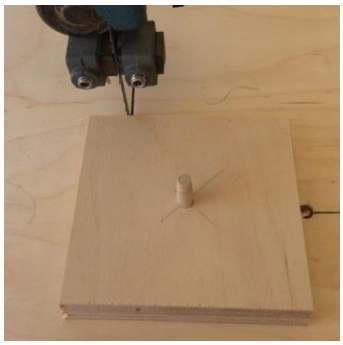


Figure 18-4.

(Note: the upper blade guide is higher than the recommended ¼" above the work piece in Figure 18-4 and the following photographs in order to better show the use of the jig. In practice it should be lower.)

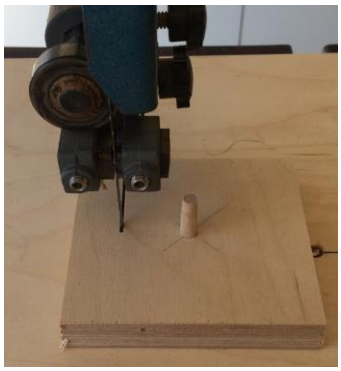


Figure 18-5.

5. Keep the jig pressed against the front of the bandsaw table as you slowly turn the blank on the pivot dowel into the moving bandsaw blade. See Figure 18-6.

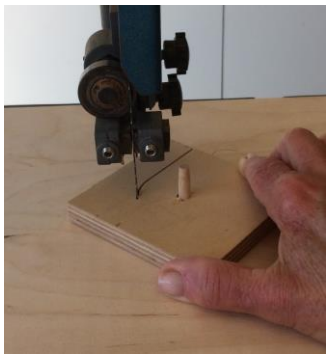


Figure 18-6.

6. When a complete circle has been cut out, stop the bandsaw blade and slide the jig off the blade through the original cut made in the blank.

Fine Tuning Jig

Keep an eye on the bandsaw blade as the blank is turned into it. The blade bending off a vertical position is an indication that the jig is out of adjustment. If this happens, stop the bandsaw and check that the center of the pivot hole is lined up with the front of the blade teeth.

Adjusting the screw in the front edge of the stop block, where it engages with the front of the bandsaw table, can help to make fine adjustments to the location of the jig.

Making More Pivot Dowel Locations

The jig described above has a row of ¼" pivot dowel holes for different size circles. There is a simple way to add more pivot hole locations or holes for circles that need a ⅜" center hole and thus need a ⅜" pivot dowel.

Simply screw a second stop block onto the original one (see Figure 18-7). This will pull the jig back the width of the added stop block, enabling another row of pivot dowel holes. To do this, it will be necessary to either remove the fine tuning screw on the original stop block or drill a hole in the back side of the additional stop block to cover this screw.

After adding the second stop block, put the jig on the bandsaw table and push it forward through the saw cut made earlier until the added stop block is stopped by the front of the bandsaw table. Now draw the new line perpendicular to the end of the bandsaw blade. Along this new line drill additional holes for pivot dowels to make the desired circle diameters and center holes. Alternatively, it is easy enough to make another one of these jigs.

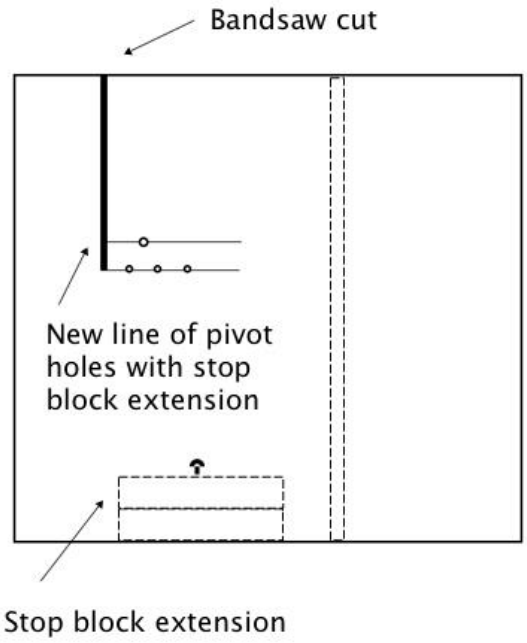


Figure 18-7.

Using a Router

In toy making, the router is used primarily for rounding over edges of toy parts. This helps to create smooth edges and child safe toys. The router is also used to shape parts when making duplicate parts, using the technique of template routing.

Since toy parts are small and hard to clamp to a work bench, using a router is not recommended unless it is stationary (attached to a router table).

Router Table

Rounding over edges or shaping parts are techniques that should be done using a router table.

To obtain the best results:

1. The router table must be flat and the insert must be flat and flush with the table. A sagging table or table insert will give uneven round overs. This will result in excessive sanding to repair the "step" created or partial round over.
2. The roundover bit must be precisely adjusted relative to the table surface to give a full round over, but without creating a "step" in the bottom surface (see Figure 18-8).
3. The router bit must be sharp and the guide roller (bearing) free turning.

Making a Router Table

Instructions for making a simple router table can be found on the internet by searching "building a router table."

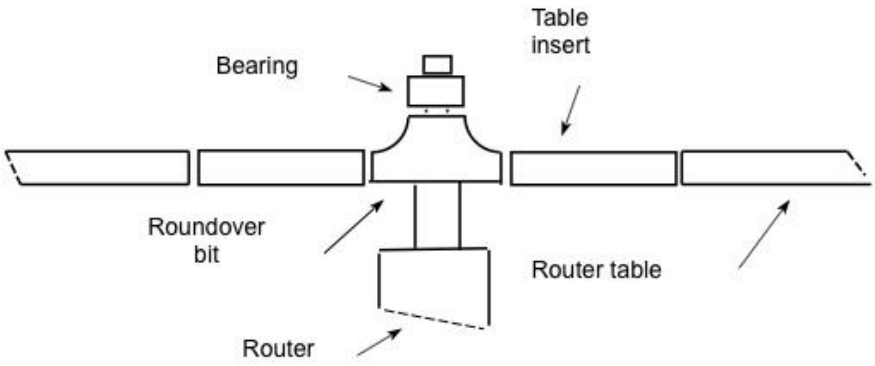


Figure 18-8. Roundover Bit Set-up

Routing Techniques

To achieve a smooth finish with few or no burn marks (some woods like cherry and maple burn easily), the following procedures will help:

1. The work piece must be moved ***against*** the rotational direction of the cutter (see Figure 18-9). It is very dangerous to move the piece with the direction of the cutter, since this may cause your work piece and your hand to be pulled into the cutter.

2. When routing small parts, it is best to use a clamp, jig, or push stick to keep your fingers a safe distance from the router bit.

3. Use only enough pressure on the work piece to maintain contact with the router bit.

4. Keep firm downward pressure on the part against the table.

5. Never stop the work piece movement against the cutter. Do the cutting in a series of overlapping sweeps.

6. The feed rate is not really critical, but too slow a rate can produce burn marks, and too fast a rate is likely to cause the finish to be rough. Reducing cutter RPM is an alternative technique.

7. When using a roundover bit, initially set the bit slightly low. After the first cut, the bit should be raised to the correct setting and the roundover re-cut. This second pass will remove a small amount of material, resulting in a cleaner cut.

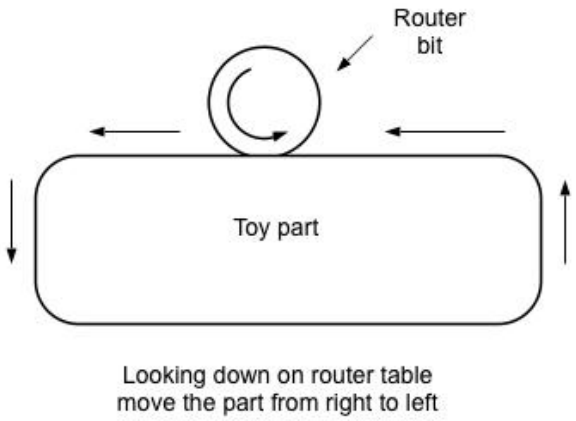


Figure 18-9. Correct Method of Feeding Work Piece into Router Bit (Top View)

Rounding Over Toy Edges

To add realism to animals, cars, etc. the edges of nearly all toy parts are rounded over. Also, the round over provides a safer edge for children who handle the toys, or who might fall on them.

The roundover size (size of roundover bit) for the toys in Part I is specified in the instructions for each toy and was chosen to suit the type of toy.

In rounding over edges, sharp router bits are a necessity to minimize sanding. Sanding out burn marks is not fun! Burn marks may be avoided by using a variable speed router. If burn marks occur, reduce router RPM up to one half. Reduce feed rate also.

Plan ahead regarding the drilling of holes in a part and the rounding over of edges. It has been recommended to drill holes before the part has been cut out from a rectangular blank, in order to have a square edge on which to register the part for drilling. However, there are cases in which the holes might interfere with the router bearing when doing round overs. In such cases, it is recommended to round over before drilling those holes, or round over by hand sanding.

Router Jigs

Methods for making large wheels have been described earlier in this chapter. This section begins by showing how to make and use a simple jig for rounding over the edges of those wheels. It concludes with illustrations showing the technique of template routing.

Wheel Roundover Jig

This jig is used on a router attached to a router table and installed with a roundover bit. It should be used after the edges of the wheel have been sanded, either by hand or using the jig for sanding wheels described in the Chapter 20, pp. 178-9.

The jig is made as follows: At the end of a piece of scrap wood about 2" wide, ¾" thick and 6" to 8" long drill a hole for a dowel which has the same size diameter as the center hole of the wheel whose edges need to be rounded over.

The dowel should be located close enough to the end of the wood such that the wheel will hang over the edge at least ¼" (see Figure 18-10). It should be no longer than the thickness of the wheel to be rounded over.

Place the wheel on the dowel (Figure 18-11). Now turn the jig over with the wheel on the dowel, turn on the router, and move the jig clockwise around the spinning roundover bit, as shown in Figure 18-12.

Figure 18-10. Wheel Roundover Jig

Figure 18-11.

Figure 18-12.

Template Routing

The technique of template routing is very useful if you want to make multiple copies of the same toy or where a toy, such as the Doll Bed (Chapter 7) requires two identical parts – the headboard and the footboard. Making a headboard is used to illustrate the procedure:

1. Begin by making a template of the part. Any wood can be used for a template, but MDF is particularly user friendly because of the ease in which it can be shaped. It pays to take the time to make a very accurate template, since the parts that will be produced will be exactly like it.

Template

2. Next, use the template to create an outline of the part on the blank of wood from which the part will be cut.

Outline on Blank

3. Now cut out the part about 1/32" outside of the outline. This is usually done on a bandsaw or scroll saw.

Rough Cut-out of Part

4. Next attach the template to the rough cut-out part. There are several ways to do this. In the case of the doll bed headboard, the template is screwed to the blank using two screws. This is possible since the headboard will eventually have four screw holes on it's surface.

Template Attached to Part

If screwing the template to the blank is not possible, either use double sided tape to attach the template to the blank or a special purpose jig.[40]

5. Finally, use a flush trim router bit with a bearing that runs against the template to trim the approximate excess $^{1}/_{32}$" from the rough cut-out of the part (Figure 18-13).

Demonstration of Template Routing

See, for example, Fine Woodworking[41]

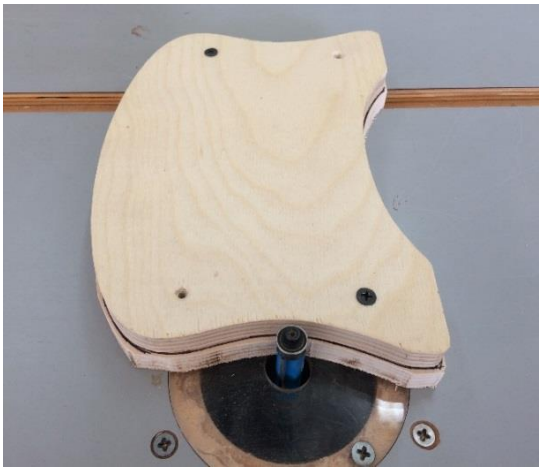


Figure 18-13. Trimming the Part

[40] See "Pattern Routing Jig," Fine Woodworking (6/2/14) or video by Matt Kenney.

[41] "Template Routing Basics," Fine Woodworking ((9/20/13) or video by Tim Rousseau.

Other Cutting Jigs

Because of safety concerns, toy builders often create jigs as they are building a toy. Following is an example of one such jig used to machine the small hubs of the Honey Bee wings (Chapter 8).

These hubs are made from 1 ¼" pieces of ½" dowel. They require a hole drilled in one end and a slot cut in the other end. Chapter 8 has descibed ways of doing these two operations. Figure 18-14 shows a jig that provides another way to cut the slots.

Making the Jig

The jig is made from a piece of wood 3" wide, 9" long and at least 1 ¼" thick. The width and length dimensions are not critical.

Along the length of one face of the board (call this the top) draw a center line. Along this line drill ½" diameter holes about 1" apart. These holes should be 1" deep and be drilled with a brad point bit to create a flat bottom.

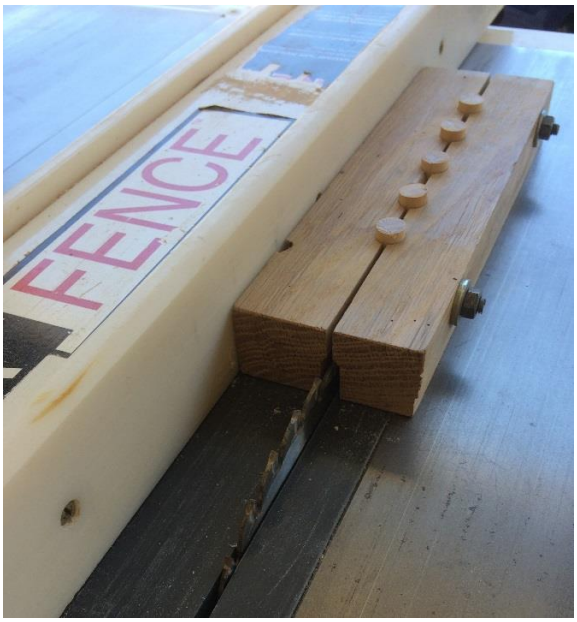


Figure 18-14. Jig to Cut Slot in Honey Bee Hubs

Next drill two ¼" holes from one side through the width. These holes should be located ½" down from the top toward each end of the jig, and counter sunk on one side.

Finally, saw the board in half, lengthwise, along the exact center of the holes and re-assemble it with two ¼" machine bolts, placing the head of the bolts in the countersunk holes.

Using the Jig

Place the 1 ¼" pieces of ½" dowel for the wing hubs of the honey bee toy into the holes, pushing them down to the bottom of the holes. Then tighten the machine bolts. Next adjust the table saw blade to a height of about ¾". **Warning:** Make sure the bolts are well above the saw blade.

Adjust the table saw fence so that the blade will cut through the middle of each hub, and make a cut as shown in Figure 18-14. The height of the blade might need to be adjusted by experimenting with the jig.

The end product will be hubs cut as shown in Figure 18-15.

Figure 18-15. Slots Cut in Honey Bee Hubs

19. Drilling

This chapter begins with a review of drilling methods, the types of drill bits used to make wooden toys, and the drill bit sizes to use. It also includes how to cut out and sand large wheels using a drill press, and some useful jigs for locating drill holes and holding small round parts for drilling.

Drilling Methods

Toy making requires smooth bores and clean entry and exits for holes, especially holes used for rotating axles. The following guidelines should help to achieve the desired results:

1. If available, use a drill press for all holes.[42] The part to be drilled should rest on a back-up board, and one of the straight edges of the part should be held or clamped against a fence. The fence, in turn, should be clamped to the drill press table.

   Figure 19-1 shows a typical set-up. In this example the drill press is fitted with a jig that includes the table and the fence.

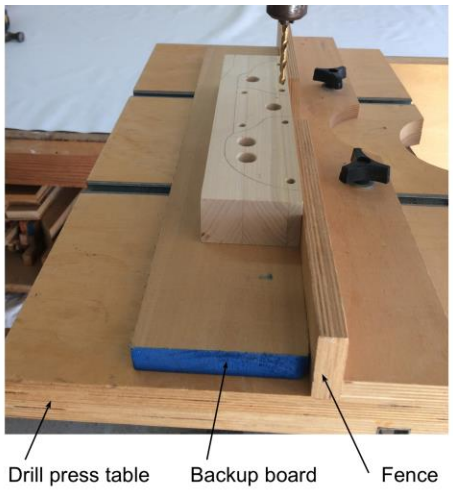


Figure 19-1. Typical Set-up

2. Try to drill holes while the wood blank is still rectangular. This will require fewer set-ups on the drill press when drilling a number of holes that are the same distance from the edge of the blank and will also speed up drilling multiple copies of the same toy.

   The wood blank for the Car Transporter (Figure 19-2) is a good example of this. All the holes have been drilled before the cars and trailer are cut out of the blank.

3. Make certain drills are sharp.

4. Tighten all three jaws on the drill chuck.

5. Use moderate feed rates and correct RPM for smooth bores (see Delta Drill Press Chart available on line).

6. Use a back-up board to eliminate splinters that are pushed out of the bottom of the drill hole as the drill exits the wood, This is known as “blowout”. Move the back up board frequently.

7. Start with a slow feed rate at entry and use a slow feed rate at exit to minimize shredding and “blowout”.

8. Clear chips often, especially in deep holes, by removing the drill bit from the hole so the chips fall out.

9. Clamp toy parts when using large drills (⅜" diameter and larger). The biggest danger is losing control when retracting the drill from the hole.

[42] With the possible exception of screw pilot holes.

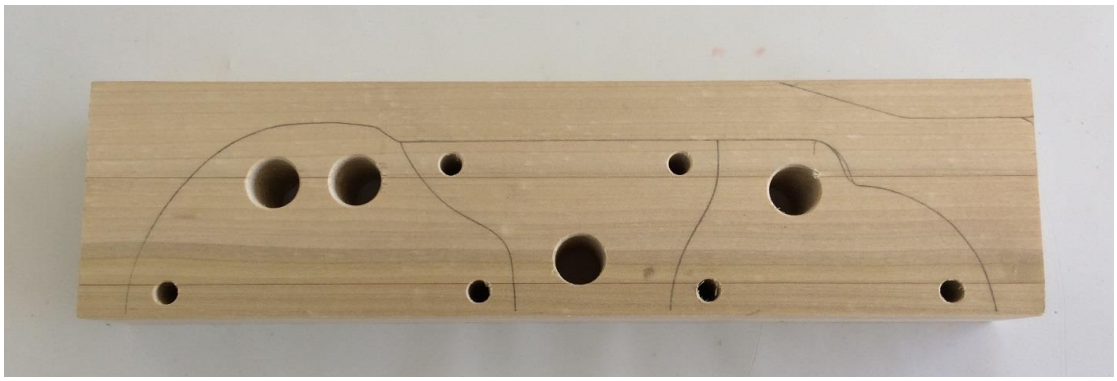


Figure 19-2. Wood Blank for Car Transporter

Types of Drill Bits

Figure 19-3 shows the common drill bits used in toy making:

Twist Bit **Brad Point Bit** **Forstner Bit** **Hole Saw** **Spade Bit**

Figure 19-3. Common Woodworking Drill Bits

Twist Drill Bits. The twist drill bit is the most common "household" bit, but it is not ideal for drilling wood. Its advantages are that it comes in a large variety of sizes, is the least expensive drill bit, is easily sharpened, and if used correctly gives very acceptable results.

Using the right speed (revolutions per minute - RPM) will help get smooth bores. Often twist bits are run too slowly. HSS (high-speed steel) bits can take lots of RPM in wood.

Sharp drills and moderate feed rates are especially important when using twist bits to achieve the smooth bores needed for axle holes.

Brad Point Drill Bits. Brad point drills are preferred over twist drills because they give smoother, more accurate bores. However, they are not available in the variety of sizes needed for all toy making operations.

Follow RPM charts when using brad point drills. Do **not** use brad point drills with drill bushings. Bushings will ruin the cutting edges of these bits.If a brad point drill is being used to drill through a piece of wood, start on one side and drill deep enough so the point of the bit just comes out the other side. Then turn the wood over and finish the hole by drilling from the other side.

Forstner Drill Bits. These drill bits are especially useful for larger diameter holes. They are the only drills that can be used for drilling on a slant surface (see Figure 19-4) or creating flat bottom holes.

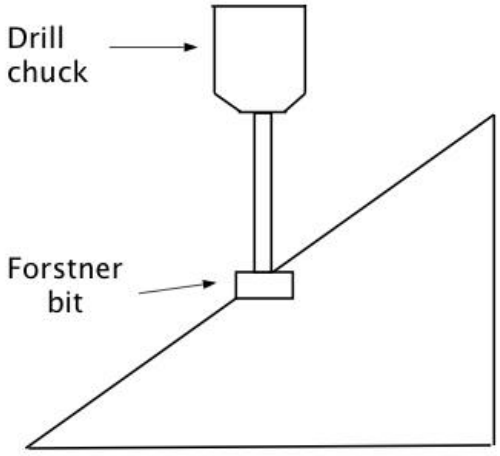


Figure 19-4. Drilling on a Slant with a Forstner Bit

When using a Forstner bit, keep the RPM down, especially for larger size drills. These bits get overheated very easily due to their design. With some kinds of wood, especially plywood, chips jam up. It is usually necessary to clear chips more frequently when using these bits.

Forstner bits can also be used for drilling an interrupted surface, as shown in Figure 19-5. This illustration shows a large hole being drilled next to and partially over a smaller hole. This was used in cutting out the cavity for the helicopter drive mechanism (Chapter 17, p. 141).

Hole Saw. If bore smoothness is not critical, large drill holes can be achieved using a hole saw. Hole saws are especially useful in toy making for cutting out large wheels. They come in a variety of sizes, from ½" to over 8" in diameter.

When a hole saw is being used to cut out a wheel, start on one side and drill almost through the wood. Then turn the wood over and finish the hole by drilling from the other side. Keep in mind that the diameter given for a hole saw is the saw's outside diameter. Therefore, use a hole saw with a diameter that is at least ⅛" larger than the diameter of the wheel you want to make.

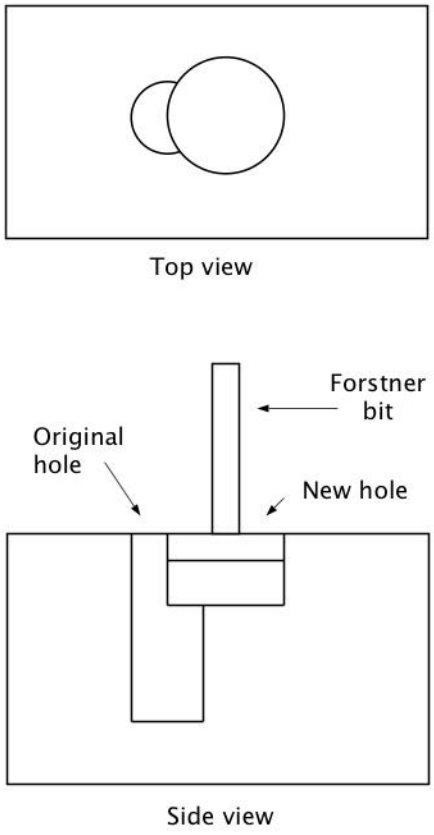


Figure 19-5. Drilling an Interrupted Surface with a Forstner Bit

Spade Drill Bit. These bits are used mostly in construction, for example, for putting holes through studs. They drill deep holes quickly.

Although seldom used in toy making because they tend to leave a ragged hole, there are occasions where they are useful. One such case occurred in cutting out the yoke for the Rolling Rattle (Chapter 16). A spade drill with spurs is preferred.

If a spade drill bit is being used to drill a through hole in a piece of wood, start on one side and drill more than half way through so the point of the drill just comes out the other side. Then turn the wood over and finish the hole by drilling from the other side.

What Size Drill to Use?

In toy making, drilled holes are usually for one of two purposes: as a way to glue one part (a dowel, wood button, or axle peg) to another; or to receive an axle (dowel or axle peg), which needs to move freely in the drilled hole.

Clearly the use of the hole is one important issue in determining the size of the hole to be drilled. Another important issue stems from the fact that dowels of a given diameter actually are seldom the exact diameter stated by the manufacturer. A given size dowel can vary enough to cause a problem in obtaining a good glue joint, even dowels from the same manufacturer as well as from one manufacturer to another.

Therefore, before drilling a hole for a glue joint or moveable axle, be certain to obtain an accurate measurement of the diameter of the dowel or the diameter of the tenon being used. (This is why it is recommend to have a caliper as one of your basic measuring instruments.) To the diameter add the following clearances:

- A hole made for a movable ¼"or ⅜" diameter dowel or an axle peg should be at least $^{1}/_{32}$" (about 0.032 inches) larger in diameter than the dowel or tenon that is to be moveable in the hole. Larger diameter dowels require more clearance.

- A hole made for a glue joint should be slightly loose – approximately 0.005 inches Larger in diameter than the dowel or tenon being glued into it.[44]

Once a drill bit has been chosen for the hole, it is recommended that a test hole be drilled in a piece of scrap wood to see how the dowel, axle peg or wood button being used fits the hole. If the hole does not seem to be satisfactory, try a different size drill bit until the fit works.

Achieving proper glue joints for parts to be glued into a hole is particularly important in order to avoid parts becoming loose and causing a potential choking hazard. Using the test for proper fits given in Chapter 2 (pp. 19) or the spacing given above to determine if a hole has a proper glue joint is strongly recommended.

The table in Chapter 2 (p. 18) gives the normal drills bits to be used with different size dowels, wheels, axle pegs and wood buttons. It is provided as a starting point in selecting the correct size drill to be used, keeping in mind the purpose for the hole (glue joint or moveable part) and the actual size of the dowel, axle peg, or wood button to be used.

The drill size suggestions provided in this table apply whether using manufactured wheels or custom made wheels. Certain "lettered" drills are particularly useful for creating good glue joints for ¼" dowels. They are D (.246" in diameter), F (.257"), and G (.261"). For gluing ⅜" dowels, the following "lettered" drills are useful: U (.358" in diameter), V (.377") and W (.386"). See Appendix A for decimal equivalents of fractional, lettered, and millimeter-sized drills.

[44] 0.005 inches is approximately the thickness of two pieces of newspaper.

Reaming Out Holes

Holes might need to be reamed out by hand for two reasons. First, to clean out any fuzz or finish (shellac, etc.) that has gotten into the hole.

Figure 19-6.

Second, to adjust the size of the hole in order to achieve a good glue joint or to enable an axle to rotate freely in it.

The easiest way to ream out holes is to use the drill bit that originally made the hole fastened in a drill chuck (see Figure 19-6). The drill chuck provides a grip for turning the bit in the hole, and gives much better leverage than trying to ream out the hole by holding a drill bit in your hand.[45]

Cutting Out and Sanding Wheels

Making Wheels on a Drill Press

To cut out a wheel from a wood blank using a hole saw, drill almost all the way through the wood from one side. Then flip the blank over and drill from the other side. The wheel that has been cut out of the blank will have a ¼" center hole.

If it needs to be enlarged to ⅜", re-drill the center hole with a ⅜" twist drill. Be sure to have the wheel securely held in a clamp because the drill will tend to grab and spin the wheel. A useful jig to hold a wheel for drilling is shown on page 170.

Sanding Wheels on a Drill Press

After a wheel has been cut out of a blank, its edges need to be sanded and rounded over. One way to sand the edges of a wheel with a ¼" center hole is to secure a ¼" threaded rod (bolt with the head cut off) into the drill press chuck and put the wheel on the bolt secured with a nut and washer. One side can be up against the chuck. Depending on the length of the bolt, more than one wheel can be put on the bolt and sanded at the same time.

Turn on the drill press, holding sandpaper against the edge of the wheel(s). Start with very coarse sandpaper and work to very fine, always holding the sandpaper on the left side - the side turning away from you. This will prevent having your hand forced back.

If the wheel has a ⅜" center hole, use a ⅜" bolt with the head cut off.

Sanding Jig

See Chapter 20 (pp. 178-9) for another way to sand wheels using a belt or disk sander and a homemade jig.

[45] Inexpensive drill chucks can be found for less than $10. Look for Jacobs and Yakamoz brands, and check on line or stores like Harbor Freight.

Drilling Holes in Small Round Objects

At times a hole must be drilled in a circular piece of wood, such as a wheel or a dowel to be used as a spacer.

This is necessary when making several of the toys in Section I. See, for example, making the spacers for the Mouse (Chapter 14) and Helicopter (Chapter 17), and enlarging the center hole of a wheel for the Helicopter.

Small round objects cannot be held by hand while drilling, and they are usually too small to clamp securely. A simple solution is to make a "wooden pliers."

Take a piece of scrap wood and drill a hole in one end the size of the object (wheel or dowel) that needs to be drilled. Using a bandsaw or a scroll saw, cut a “V” wedge from the hole to the end of the piece of wood. See Figure 19-7.

The wedge forms a handle that can be griped or clamped to hold the object that needs to be drilled.

The wheel in Figure 19-6 has a ¼" center hole that needs to be enlarged for a ⅜" axle. Place the wheel in the pliers, grip the ends to hold the wheel securely, then drill the larger center hole, as shown in Figure 19-8.

Figure 19-7. Wood Pliers to Hold Round Objects

If the end of the pliers shows signs of breaking when gripped or clamped too tighten on the object, a bolt can be placed through the end to hold it securely.

Round over the edges of the handle to make the pliers more comfortable to hold.

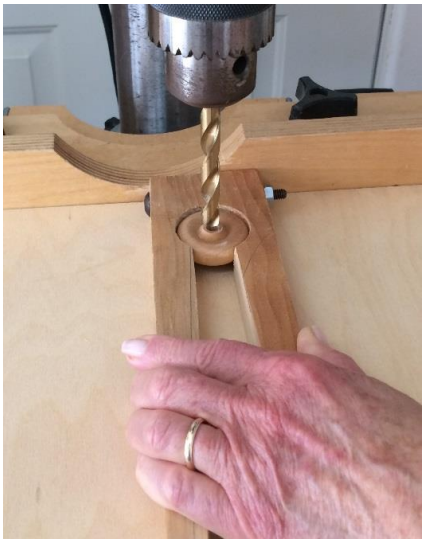


Figure 19-8. Wood Pliers in Action

Other Jigs to Assist in Drilling

Drilling jigs are useful for several reasons. They safely hold small toy pieces for drilling, they can make the location of holes more accurate and they can speed up the construction process.

When making duplicates of the same toy, a jig can help to assure that parts are interchangeable. Woodworkers tend to develop jigs as needed when working on a project. Sometimes they are never used again. However, here are some examples of toy making jigs created by members of the SDFWA Toy Program that have been used for many years.

Templates for Marking Holes

If many of the same toy are going to be made, either now or in the future, it will be helpful to have a template for marking the location of holes to be drilled in the body or parts of the toy, especially if there are a number of holes to be drilled.

One such template is shown in Figure 19-9. This template is used to locate the 10 holes that need to be drilled in the wood blank for the trailer and cars of the Car Transporter toy (Chapter 12).

The template was made from a piece of scrap wood the same width and length as the car hauler blank. The thickness is not critical – ¼" to ¾" will do. The centers of the 10 holes are located on the template and holes are drilled for screws at those locations. The screws need to be longer than the thickness of the template so that they poke through to serve like a nail punch for locating the holes to be drilled in a wood blank.

To use the template, place it on a wood blank for this toy and press or lightly hammer the template to mark the holes on the blank. Then drill the holes.

Another example of a template to mark the holes to be drilled into a toy is shown in Figure 19-10. Here two templates where used for the School Bus (Chapter 9) – one for the body (marking 10 holes) and one for the roof (6 holes).

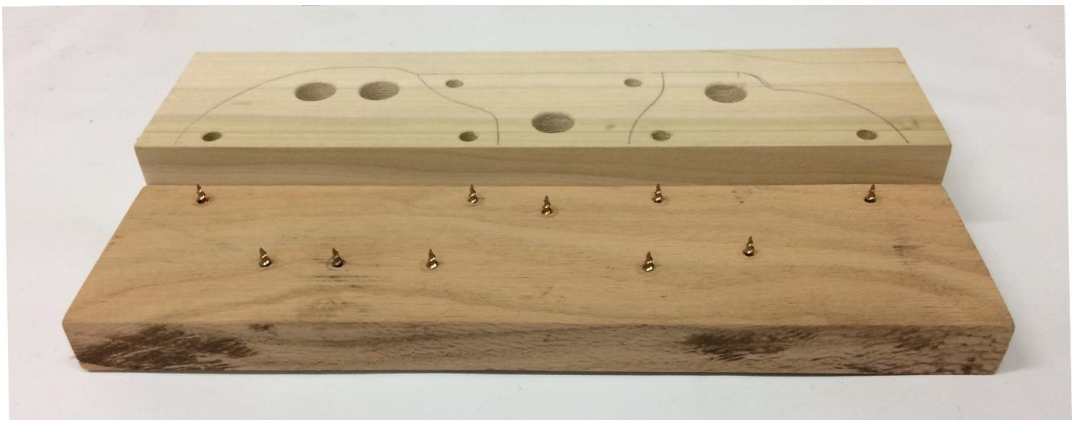


Figure 19-9. Template for Marking Holes in Car Transporter Blank

Figure 19-10. School Bus Hole Drilling Templates

Hole for Push Stick

A number of the toys described in Part I required a ½" hole for a push stick. Often this hole needs to be drilled at an angle on an odd shape on the top of the toy's body.

Unlike other holes that are drilled in the body of a toy when it is a rectangular blank, this hole can not be drilled until the body has been cut out of the blank, making it very difficult to hold the toy for drilling the push stick hole into the edge.

What is needed is a special purpose jig that can hold the toy's body at the correct angle for the push stick hole. An example of such a jig follows (Figure 19-11).

This jig is used to drill the hole behind the head of the Duck (Chapter 6). Such jigs are simple to make. They require a vertical stand to which is attached a piece of wood in the shape of the bottom of the toy. This piece is rotated in the desired direction for drilling the push stick hole and attached to the stand. The stand can then be clamped to the drill press table and the toy placed on it for drilling.

Figure 19-11. Drilling the Push Stick Hole in the Duck

Other Angled Holes

Push sticks are not the only holes drilled at an odd angle. Another example are the holes for the antenna of the Honey Bee (Chapter 8). Like the push stick, these holes need to be drilled into the edge of the toy after the body is cut out.

A further complication is that these holes are not perpendicular to the edge. A special purpose jig used to hold the body of the bee and to achieve the correct angle is shown in Figure 19-12.

The sides of the jig are at a 10-degree angle to the base, tilting outward from each side (See Figure 19-12A).

The body of the honey bee is placed in the jig and wedged up against one side (Figure 19-12B). The jig is put up against the fence of a drill press (Figure 19-12C) and the antenna hole is drilled into that side.

Then the wedge is removed and the body is wedged against the opposite side of the jig and that hole is drilled.

A **B** **C**

Figure 19-12. Jig for Drilling Honey Bee Antenna Holes

Doll Bed Drilling Jig

When a toy has mutlitple similar parts, it is useful to have a jig that can help to make the parts interchangeable and to achieve accurate hole locations.

The final example of a special purpose drilling jig is one that is used to make the three $^{9}/_{32}$" holes in each of the four bed rails and the six ½" holes in the bed bottom of the Doll Bed (see Chapter 7).

The jig is shown in Figure 19-13. Instructions for making and using it follow.

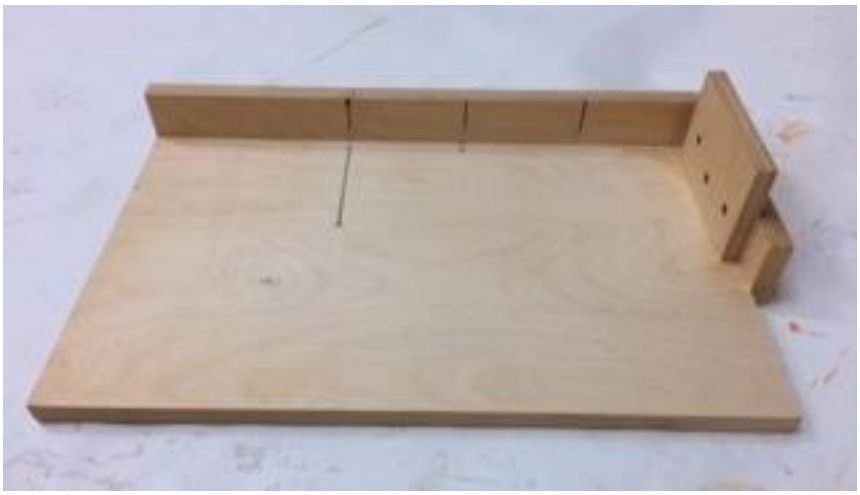


Figure 19-13. Doll Bed Rail and Base Drilling Jig

Making the Doll Bed Drilling Jig

The jig, shown in Figure 19-13, is made as follows:

1. Use a ½" to ⅜" thick piece of plywood or MDF that is at least 8" wide and 14" long for a base.

2. On one of the long (14") edges attach a fence that comes approximately 1" above the base. It can be made out of the same material used for the base or any scrap wood and can be attached to the edge of the base using dry-wall screws.

3. With the base and fence away from you, attach another fence on the right (short) side of the base. It should also rise about 1" above the base and should be about 6" long. Attach this side fence to the edge of the base and to the end of the longer side fence with drywall screws.

4. Attach a piece ½" thick wood of any type to the inside of the short side fence to serve as a spacer. Make the spacer about 4" long and 2" high so that it can be easily screwed to the short side fence on the inside of the base. It needs to be positioned exactly ⅝" from the long side fence so that a ⅝"wide bed rail can fit between its edge and the long side fence.

5. Measuring from the side fence (not the ½" spacer), place three marks on the long fence, each 3 ½" apart.

6. Cut a 3 ½" spacer from one of the pieces of wood used to make the rails. The dimensions of this spacer need to be 3 ½" long, ⅝" wide, and ¾" thick. Cut a second spacer that is 3 ½" wide with any length and thickness.

Using the Jig

Following are instructions for using the Doll Bed rail and base drilling jig:

1. After putting a $^{9}/_{32}$" drill bit into the chuck of the drill press, clamp the jig on the drill press table such that the tip of the drill bit is lined up with the third 3 ½" mark on the base (from the right side) and is $^{5}/_{16}$" from the long side fence (see left side photo in Figure 19-14).

   The dark line on the base in Figure 19-13 is the line along which the drill is to be located. Once the jig is properly lined up and clamped, it will remain in that location until all three holes are drilled into all the bed rails.

2. A bed rail is placed along the long side fence as shown in the right photo of Figure 19-14, slipping its end in the slot between the ½" spacer attached to the short side fence and the long side fence.

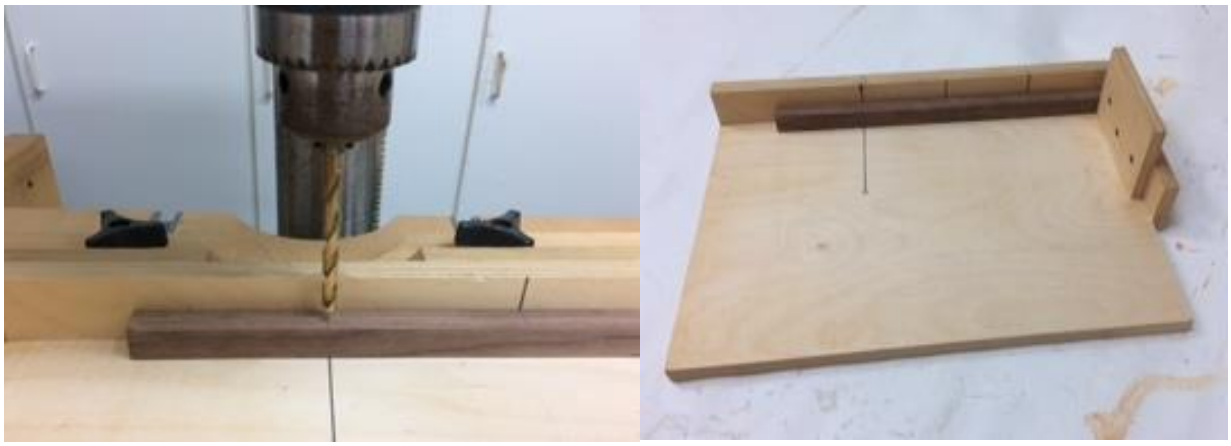


Figure 19-14. Drilling Three Holes for the Bed Rail Spacers

3. Drill a 9/32" hole ½" deep (the left hole on the rail). Next rotate the rail 180 degrees to drill the 9/32" hole on what was the right end. The jig should remain clamped in place. Only the bed rail is moved for drilling each successive hole.

4. Remove the rail and replace it with the 3 ½" spacer. Then put the rail up against the spacer and drill the 9/32" hole in the center of the rail (Figure 19-15). This completes drilling three holes on one side of the rail.

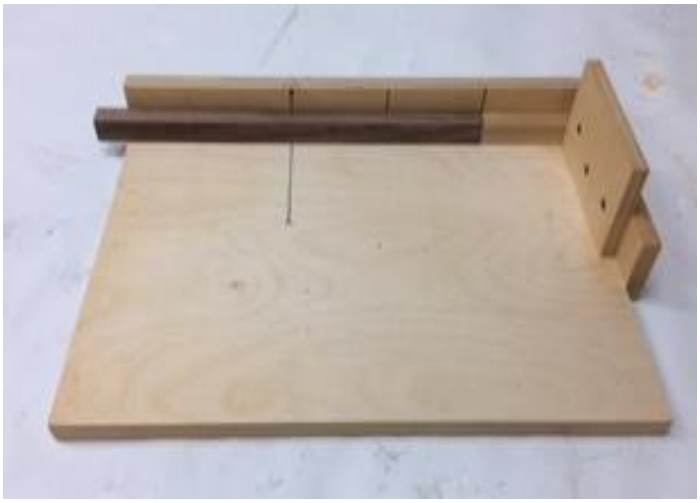


Figure 19-15. Drilling Center Hole in Rail

5. Repeat for all the rails that need to be drilled. Recall that each bed uses four rails.

6. Replace the 9/32" drill bit with a ½" brad point or Forstner drill bit. Clamp the jig on the drill press table such that the tip of the drill bit is once again lined up with the third 3 ½" mark on the base of the jig and is ½" from the long side fence.

7. Place a bed base on the jig with its narrow end against the ½" spacer on the right side, as show in the left photo of Figure 19-16.

8. If more than one bed is being made, place a second base on top of the first. It is possible to drill the ½" holes in three or four bases at one time, but do not drill through the bottom base. It serves as a back-up board to prevent splintering.

9. As with the rails, flip the board 180 degrees to drill the hole on the other end, then place the 3 ½" x 3 ½" spacer up against the right side and place the bed base against it to drill the center ½" hole. See the right photo in Figure 19-16.

10. Flip the bed base over and repeat the ½" holes on the other side of the base.

Figure 19-16. Drilling the Doll Bed Base

20. Sanding

At this point all the parts of a toy have been made. The next step is to be certain these parts are ready to have paint or a clear finish applied. Rough edges, saw marks, and any defects must be addressed by sanding and perhaps patching before finishing can begin.

In addition, if edges have not been rounded over using a router, sanding the edges to create roundovers will be necessary. Proper sanding is key to a quality looking toy. Like most woodworking projects, sanding, finishing and assembly take about one half the total time in producing the project.

Patching and Sanding

Patch defects prior to sanding. This way patch overruns will be removed for a uniform finish. Match the wood color to a reasonable degree if using a clear finish coat.

Sanding begins with coarse sand paper (60 to 80 grit) used to sand out saw and other machining marks. Employ power sanding as much as possible for eliminating machine marks (surface roughness) and for "fine tuning" (smoothing out) contours that were cut on the band saw.

Sand with the grain. Use disk sanding sparingly because circular marks are hard to remove. Belt, random orbit and oscillating spindle sanders all work very well.

As a final step before applying finish, hand sand all parts including rounded over edges with 120 to 150 grit sandpaper. Remove all tool burn marks if not already removed. Break any sharp edges or corners not rounded.

Between Coats of Finish

A fine or extra fine foam pad works well to smooth the first coat (sealer coat) of finish. Shellac is usually used for this first coat, and it has the tendency to raise the wood grain. However, the grain can be easily smoothed with a foam sanding pad.

Sand very lightly on edges and corners. If the shellac sealer is removed, the final coat of water-based polyurethane will leave blotchy light-colored areas.

Sanding Jigs

There are several jigs that are very useful in sanding small parts. The first, referred to in Chapter 18, is used to sand wheels cut out freehand, on a bandsaw, or by a hole saw. The second is used to round over or chamfer the ends of dowels.

Sometimes a special purpose jig needs to be created for sanding a very small toy part. An example is given at the end of this chapter.

Wheel Sanding Jig

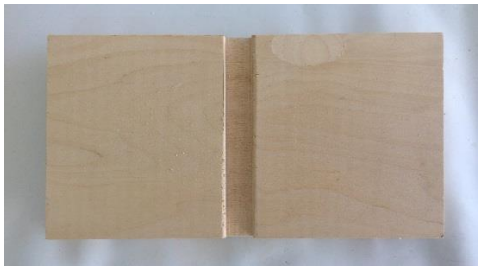
A way to sand wheels using the drill press was described in Chapter 19. Another approach to sanding the edges of wheels and making sure they are round is to use a jig resting in front of a belt or disk sander. Figure 20-1 shows the set-up.

Following are the steps to make this jig. It is assumed that there is a table or platform with a miter slot in front of the vertical belt or disk sander. It is also assumed that the slot is parallel to the sander.

Making the Jig

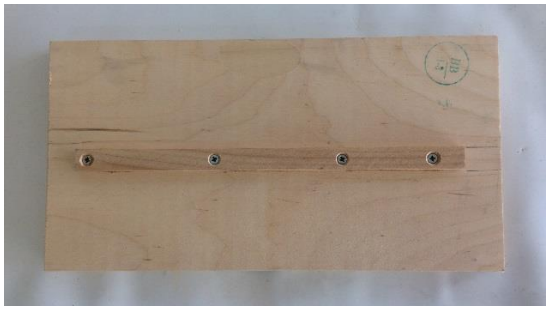
1. The base of the jig consists of a piece of ¾" plywood or MDF a little larger than the platform in front of belt or disk sander.

2. Cut a dado perpendicular to the sander in the center of the base about 3/8" deep. This will be the top of the base.



Top of Base

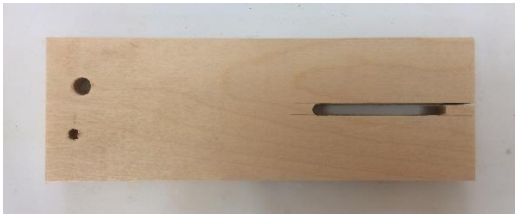
3. Cut a strip of wood the length of the base to fit the miter slot in the platform. Glue and screw the strip to the bottom of the base such that the base is located close to but not touching the sandpaper on the belt or disk sander.



Bottom of Base

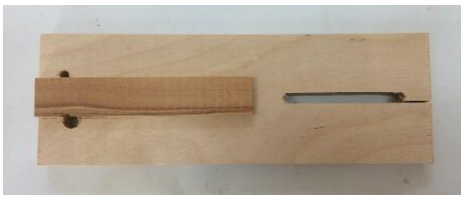
4. Cut another piece of plywood 3"wide by 10" long. This will serve as "slider" holding the wheel to be sanded. At one end of the slider drill two holes for posts, one ¼" in diameter and the other ⅜". Initially drill these holes about ½" from the end of the slider. More holes might need to be added later, depending on the size of wheels being sanded.

5. At the other end of the slider drill a centered ¼" hole ¾" from the end. Drill another centered ¼" hole 3 ¾" from the same end. On a bandsaw or scroll saw connect the holes cutting out a slot ¼" wide. A ¼" carriage bolt will be put through this slot. The slider should now look as follows:



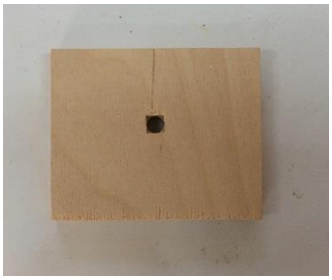
Top of Slider

6. Next cut a strip of wood to fit the dado in the base that is perpendicular to the sander. Its thickness should be less than the depth of the dado. Glue this strip to the bottom of the slider from the end where the two post holes where drilled. Its length should extend to the grove cut in step 5 and it should be centered and parallel to the long side of the slider. The bottom of the slider should now look as follows:



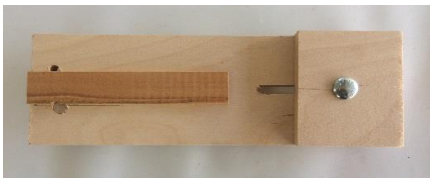
Bottom of Slider

7. Cut another piece of plywood 2" x 3" and drill a ¼" hole at it's center. This serves as a stop block and will be used to adjust the length of the slider.



Stop Block

8. Insert a ¼" carriage through the stop block and into the ¼" slot in the slider. Place a washer and wing nut on the other end. The bolt needs to be about 1" longer than the sum of the thicknesses of the slider and the stop block.



Bottom of Assembled Slider

9. Cut a dowel to serve as a post (either ¼" or ⅜"in diameter, depending on the center hole of the circle to be sanded). The post should be long enough to protrude about an 1" above the slider after it is put into the hole at the end of the slider.

Top of Slider with Post and Stop Block Attached Underneath

Using the Jig

1. With the power off, place the wheel to be sanded on the post and set the stop block against the base so the wheel just touches the sander. Tighten the wing nut to set the position of the wheel. Now move the slider with wheel back from the sander, turn on the power, and slowly slide the wheel forward, rotating the wheel as it comes in contact with the sander (see Figure 20-1).

2. If all edges of the wheel are not being sanded, turn the power off, loosen the wing nut and set the stop block so the wheel is closer to the sander.

3. **Important Note:** Be sure to keep the end of the slider within ½" of the sander to keep the wheel from tipping. This can be done by drilling other holes for the "post dowel" along the length of the slider. Just remove the post from one hole and insert it into another.

Figure 20 – 1. Wheel Sanding Jig

Dowel Sanding and Chamfering Jig

There are times when the end of a dowel will have to be sanded square if the end is rough or was poorly cut off from a long piece of dowel, or it might need to be rounded or chamfered for a wheel axle.

When using a dowel as an axle for a car or truck wheel, rounding over or chamfering the end before gluing into the wheel gives a more finished look (Figure 20-2) and might make the wheel appear to have a hub cap.

Figure 20-2. Chamfered Dowel to Form a Hub Cap

Making the Jig

This jig is made from two pieces of wood. The horizontal base is about 9" long, 1 ½" wide, and at least ½" thick. The exact dimensions are not critical. The vertical piece attached to the end should be about 2 ½" x 2 ½", with a thickness of at least ¾".

On the top of the vertical piece are notches in which a dowel will rest. The notches can be cut with a round or triangular file, or using a bandsaw set at 45 degrees.

The jig in Figure 20-3 has three notches. The center notch is parallel to the sides. The notches on either side are at a 45-degree angle to the side. The notch on the right is large enough to hold ⅜"dowel, the one on the left is a bit narrower for a ¼" dowel. These notches can be modified to suit your needs.

Figure 20-3. Dowel Sanding/ Chamfering Jig

Once the two pieces of wood have been prepared, attach the vertical notched piece to the end of the horizontal base using two screws through the bottom of the base.

Using the Jig

Clamp the jig to the table in front of a belt or disk sander with the notched end almost touching the sandpaper (see Figure 20-4).

Figure 20-4. Jig Clamped to Table

A dowel whose end is to be sanded square is placed in the center notch perpendicular to the sandpaper. Rest a finger of one hand on top of the dowel to keep it horizontal. Turn the sander on and with the other hand gently push the end of the dowel while turning it toward the sander to achieve a smooth, squared-off end.

To chamfer or round over the end of a dowel, place the dowel in either the left or right side notch again holding it with a finger from one hand and pushing the dowel toward the sander with the other hand while slowly turning the dowel. See Figure 20-5.

Figure 20-5. Chamfering the End of a Dowel

A Special Purpose Chamfer Jig for Small Parts

This jig puts a chamfer on a very small part – the 1 ¼" long by ½" diameter dowels used to make the wing hubs of the Honey Bee (Chapter 8).

Making the Jig

1. Start with a piece of 1" thick scrap wood about 5" x 5". One way to get this thickness is to surface glue together two pieces of ½" plywood.

2. Toward the top of one edge draw two parallel lines, ½" apart, and at a 45-degree angle to the edge. The upper line should be 1 ½" long; the lower line should be ⅞" long.

3. Chisel out a ½" deep hole between the two lines. Next hammer a finishing nail as close to the edge as possible.

4. Repeat with a second set of parallel lines about 1" below the first set (Figure 20-6).

Using the Jig

1. Place the 1 ¼" wing hub dowels in the jig (Figure 20-7). The notches in the end of the dowels will already have been cut. (See Chapter 8 or the special purpose jig at the end of Chapter 18 on ways to cut this notch.)

2. Put the jig on the platform in front of a belt sander, turn on the sander, and gradually bring the jig up against the sandpaper to chamfer one side of the dowel (Figure 20-8).

3. Remove the jig from the platform, turn the dowel over and repeat the chamfer on the other side of the notch.

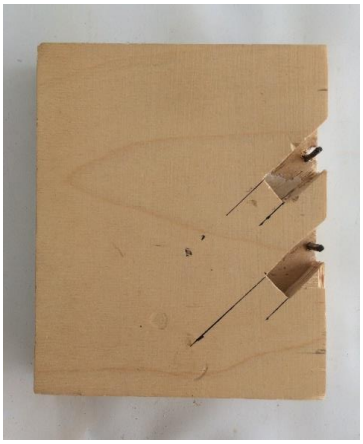


Figure 20-6.

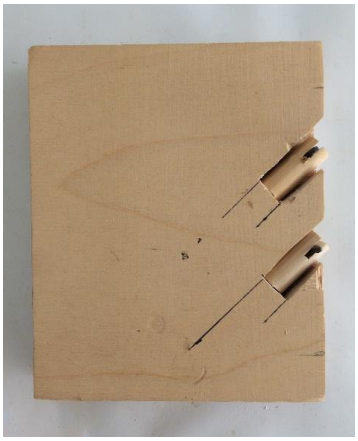


Figure 20-7.

Figure 20-8.

21. Finishing

All finishes used in toy making must be non-toxic when dry. Shellac for sealing, acylic craft paint, and water-based polyurethane for a hard clear finish are safe to use on toys. Some spray paints and oil based finishes are also safe – check the labels.

Applying finish to a toy is not essential, but it will add to the attractiveness of the toy and make it easier to keep it clean. There are, of course, many different types of finishes that could be used. This chapter describes the ones we have used for many years that have been found to provide very good results.

Thorough sanding is required before finishing. Then mask off any ends of parts that will be glued, for example the end of an axle peg. Parts of a toy are usually finished separately before the toy is assembled. There are exceptions, however, when the toy or some parts are assembled before finishing.

Clear Finishes

Most toys are made out of hardwoods, so they deserve a clear finish to show off their beauty. One of the attactions of wooden toys is seeing the interesting wood grain from which they are made. Although children enjoy playing with colorful toys, the interesting shades of natural wood grain can also be appealing.

Shellac

Shellac is recommended as the first coat of finish. It serves to seal the wood. It will also bring out the color and grain of wood. This is particularly important if the next coat is a clear finish. Shellac can be wiped on or brushed on. However, shellac tends to raise the grain of wood, that is, cause the surface of the wood to feel rough. Once dry, the piece will need to be lightly sanded with 320 grit sandpaper or a fine sanding pad before applying the next coat of finish. Don't forget to clean off the dust after sanding.

The foam pad minimizes cutting through the shellac at the edges. In addition to removing raised wood grain, sanding also helps bond the next coat of finish (polylurethane or paint).

In using shellac apply a two-pound cut of de-waxed shellac with a rag, brush, or spray gun. The purpose for using a de-waxed shellac is to assure that the final coat will create a good bond with the sealer.[46]

If the plan is to use a stain on the toy, do not use shellac.

Polyurethane[47]

The preferred final coat is water-based gloss or semi-gloss polyurethane, applied by brush or spray gun. Water-based polyurethane gives a shiny, hardwearing finish to toys. It also dries quickly, and a second coat can often be applied without sanding again, if done within several hours of the first coat.

Both shellac and water-based polyurethane are environmentally friendly coatings. If the toy or part of the toy is to be painted, it is still recommended that it first be sealed with shellac. It is also a good idea to apply a coat of water-based polyurethane after the paint has dried, especially if an acrylic craft paint or flat paint has been used.

[46] Zinsser makes a shellac called Seal Coat which is 100% wax free. It is available at most paint stores.

[47] Many companies make water-based polyurethane. If you prefer an oil-based finish, the Salad Bowl Finish by General Finishes is non-toxic when cured.

Color on Toys

Toys don't need to be painted. Most of the toys described in Part I were made out of good quality hardwoods. The natural variations in the grains of the wood from which they were made can be very attractive.

However, it is also true that toys are appealing to children when they are painted, stained, or decorated in bright colors. See for example Small Cars and Trucks (Figures 3-1 and 3-4), Push Duck (Figure 6-1), Honey Bee (Figure 8-1), School Bus (Figure 9-1), Hopping Frogs (Figure 11-1), Grasshopper (Figure 13-1), and Mouse (Figure 14-1).

Following are some things to consider when painting toys:

1. Mask off surfaces to be glued.
2. If using quick drying spray paint, do so from several angles for good coverage. As soon as the part sprayed is dry, flip it over and spray the reverse side.
3. If a second coat is required, sand lightly with super fine sanding pads or 320 grit sandpaper.
4. Acrylic craft paint usually takes longer to dry than paint from a spray can. Be certain the part painted is thoroughly dry before turning over to paint the reverse side.
5. Unless the spray paint is high gloss, a final clear coat of water-based polyurethane is recommended. To obtain a good clear finish with polyrethane, hand painting works well and is quick.

Creating Eyes

There are seven toys in Part I that needed eyes. The instructions for those toys gave four methods to create eyes: painting the eye direcly on the toy, leaving a hole for the eye, using a painted axle peg or wood button for the eye, or using a plastic (purchased) eye. In some cases only one method could be used. In other cases there are choices.

Eyes Painted Directly on the Toy

The Circle Animal Puzzle, Figure 5-1, has an eye that is painted directly on one of the puzzle pieces. It was also suggested in the instructions that this eye could simply be represented by a hole drilled through one of the pieces. The Honey Bee (Figure 8-1) is another example of an eye painted directly on the face of the toy.

Painted Axle Peg or Wood Button

The head of a $^{7}/_{32}$" axle peg is approximately ⅜" in diameter. It makes an ideal small eye. This type of eye was used for the Hopping Frogs (Figure 11-1). In this case the axle peg was painted yellow. Once dry a black cross, representing the pupil, was drawn on the yellow eye using a permanent marker.

Another example is the Grasshopper shown in Figure 13-1. It has a $^{7}/_{32}$" axle peg eye painted red. For slightly larger eyes, use a $^{11}/_{32}$" axle peg. It's head is approximately ½" in diameter. This is the type of eye used by the Grasshopper in Figure 13-5. The ½" wood mushroom button can also be used to create this larger size eye.

Plastic (Purchased) Eyes

The Push Duck (Figure 6-1) and the Mouse (Figure 14-1) show the use of a plastic eye. These type of eyes, purchased from craft suppliers, often come with a tenon and can be glued to the toy the same way an axle peg eye would be glued. Without a tenon they would be glued directly to body.

Choices for Eyes

Most of the examples sited thus far allow for choices in how to create eyes for the toy. However, this was not the case for the Hippo (Figure 15-1) which uses an eye that must be an axle peg. Here the axle peg serves to allow the jaw to rotate, as well as being the eye.

Painted Decorations

The entire toy does not need to be painted to make it attractive. In many cases a small amount of decoration will suffice. Examples of this are the Weedwacker (Figure 4-1), where only the tips of the blades have color, and the Rolling Rattle (Figure 16-1), where only the rattles are painted.

In the case of the Hippo (Figure 15-1), just the eyes and teeth were painted, and this small amount of paint makes the color stand out even more.

The Doll bed/cradle presents a unique situation for decorating. We like to have some color on the headboard or footboard or both, but not all designs will work. If you paint a decoration on the headboard or footboard when the toy is a bed, it might look very strange when the toy is turned over to become a cradle. For this reason we have found that flowers work very well, or some abstract design.

In painting a child's name on the bed, we have found it works best to paint the name twice, first in a curve that follows the curve of the headboard when the toy is a bed, then as a similar curve when the bed is turned over to become a cradle (see Figure 7-1). This way the name can be read in each direction.

Jigs Used in Finishing

The remainder of this chapter shows some simple jigs that can be useful when finising toys.

Whether wiping, brushing, or spraying on the finish, lay the parts on triangular strips of wood (Figure 21-1). This technique maximizes air circulation during drying, and minimizes contact with the surface of the part.

The triangular strips can be ripped out of ¾" square stock. Sand the strips enough to eliminate shreds and splinters of wood.

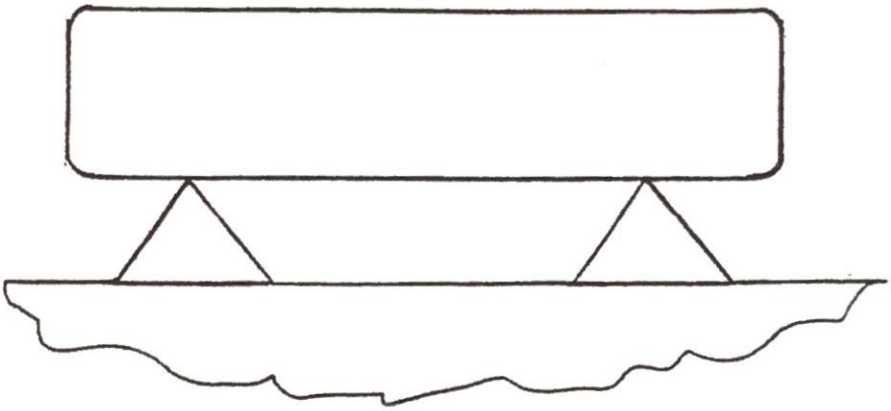


Figure 21-1.

Finishing Wheels

There are some easy to make jigs to help with the finishing of wheels. Wheels that have not been glued in place can be strung on undersized dowels and suspended across a notched cardboard box to hold them in place (Figure 21-2), or placed on small pieces of tapered dowels inserted in holes in a piece of scrap wood (Figure 21-3). A pencil sharpener is an easy way to taper the dowels.

Figure 21-2.

Figure 21-3.

The notched cardboard box will also work for the body of a toy that has more than one through hole, for example, a car. In this case use two undersized dowels to support the car, one in each axle.

For wheels that have been glued to an axle, drill holes in a piece of scrap wood slightly larger than the diameter of the axle and stand the axles with wheels attached in the holes (Figure 21-4).

Figure 21-4.

Finishing the Heads of Axle Pegs

When sealing or painting the heads of axle pegs, it is important to keep the tenon clear of finish.

First, cut the tenons of the pegs to the required length, if this is necessary. Then smooth or break the edges that were cut off.

Use a painting board (Figure 21-5) when applying the finish. The painting board is simply a piece of Masonite or scrap wood. Drill $^{5}/_{16}$" diameter or $^{7}/_{16}$" diameter holes into the board, depending on the size of axle pegs.

Insert the pegs into the holes. Their heads should be flush with the top of the board. Then set the board on supports on top of a drop cloth, or attach it to two supports.

Apply the finish to the heads of the pegs. During the drying process, push the pegs upward a couple of times to avoid the heads adhering to the board. When dry, simply place the board on a clean surface, turn it over, and the pegs will all pop out for retrieval.

Figure 21-5.

22. Assemble

With all construction, including sub-assemblies, and finishing completed, it is time to assemble the parts. Some parts are glued in place, for example the mouse ears to the mouse head. In such cases this could be done before or after finish is applied, depending on how the parts are being finished.

In practically all cases, however, assembly involves dowels, wood buttons, or axle pegs being glued into wheels, legs, or the body of the toy. These final steps are most important because they will assure the toy is fully functional, that is, the movement of the wheels and other parts work as intended. If they don't, see the trouble shooting suggestions and corrective measures at the end of this chapter.

Wheels on Dowels

Wheels glued to dowels are designed to rotate in a hole in the body of a toy. The folowing description assumes wheels are being attached to the axles of a car, but the same procedure would apply to any toy with wheels:

1. Sand the whole dowel being used for this project with 220 or 320 grit sandpaper **before** cutting it into axles.

2. Ream holes by hand to remove paint and fuzz. When reaming out wheel center holes, select a drill bit that will create a hole that makes a good glue joint with the axle being used. Don't forget to ream out the holes in the body of the car in which axles must freely rotate.

Glue Joints

See Chapter 2 (p. 19) on testing and achieving good glue joints.

Reaming Out Holes

See Chapter 19, p. 169.

3. Cut the dowel over-size that is being used for the axle. Sand one end either squared-off or chamfered. Figure 22-1 shows examples of these two ways to finish the ends of axles. The axles of the two wheels from the left are squared-off; the one on the right is chamfered to look like a hubcap.

Sanding Ends of Dowels

Chapter 20 (pp. 180-1) describes a jig that can be used to sand the ends of axles to give them a squared off or rounded look.

4. Dry assemble one wheel on the end of the axle that was sanded. Size the axle length by inserting the axle with wheel attached through the axle hole with a washer and a spacer[48] on the side of the axle where the wheel is attached.

[48] The spacers should be about 1/32" thick (.02 - .04"). The plastic clip that is used to seal the outer bag of a loaf of bread makes a good spacer or A piece of cardboard from a cereal box will also work.

5. On the other side of the car insert on the axle the second wheel up against a washer, spacer, and the body of the car. Mark the location where the axle is to be trimmed (Figure 22-2). If the end is to be chamfered, place the mark about 1/8" from the edge of the wheel; if squared-off place the mark at the edge of the wheel.

6. Disassemble the wheels and axle from the car and trim the axle where marked. Sand the end and break (round over) the corners or chamfer the end.

7. Glue one wheel to one end of the axle. (See gluing suggestions in the next section). Allow the glue to set.

8. Re-assemble the axle with one wheel attached (Figure 22-3), making sure to put a washer and spacer on each side of the body. Use the instructions given in the next section for attaching the second wheel. Let the glue set. When dry remove the spacers and test the rotation of the wheels.

Figure 22-1. Squared off and Chamfered Axles

Figure 22-2.

Figure 22-3.

Another Approach to Sizing Axles

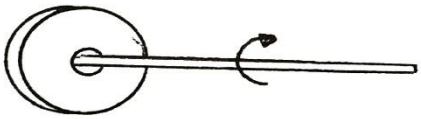
Rather than cutting the axle oversize, then cutting it to fit the vehicle once one wheel has been dry assembled to the axle, another approach is to cut the axle to length before assembling the wheels. (This was done in Chapter 12, Car Transporter.)

This approach requires careful measurements that must include the width of the vehicle, and the width of two wheels, two washers, and two spacers. To this length add ¼" if the ends of the axles are to be chamfered to make them look like hubcaps.

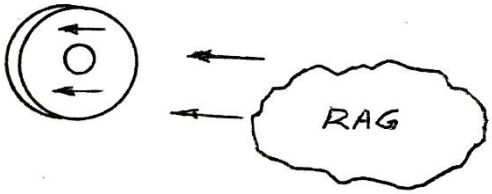
Gluing Wheels onto Axles

The following procedure assumes that paint or a clear finish has already been applied to the wheel and the center hole of the wheel has been reamed out to remove paint and fuzz.

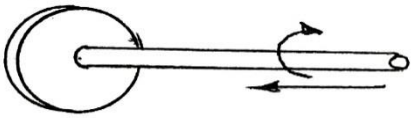
1. Put glue in wheel hole using a toothpick, nail, or piece of ⅛" dowel.



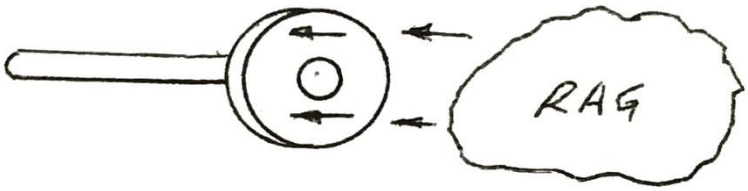
2. Wipe off excess glue from the **inside** of the wheel.



3. Insert axle (dowel) from the **inside** of the wheel.



4. Wipe off excess glue pushed to the outside of wheel.



Affixing Toy Parts with Axle Pegs

The following steps assume the body and wheels (or other part) are already finished. It is also assumed that a proper size hole has been drilled into the body, the hole has been reamed out after painting, and the axle peg has been tested in the hole to assure it will make a good glue joint in the hole.

1. Put glue in the hole with a nail, toothpick, or small ⅛" dowel. Smear the glue around the inside of the hole.

2. Wipe off excess glue from the outside of the hole.

3. Assemble by placing the part (usuallly a wheel) along with a washer and spacer (if called for) onto the axle peg. Insert the axle peg with the wheel, washer, and spacer into the hole. See Figure 22-4).

4. Allow glue to set for at least 15 minutes.

5. Test that glued part moves properly.

Note: Axle peg tenons may need to be shortened, depending on the width of the part in which they will be placed.

Figure 22-4.

Trouble Shooting and Corrective Actions

Attention to the gluing and assembling steps in this chapter will help to assure good results. However, if the assembly of parts is not going well, such as an axle not moving freely when fitting in the body of a toy, it will be necessary to take corrective action (not a hammer!). Following are some general guidelines for preventing or solving problems in assembling toys:

1. If there is a problem with a part, analyze it and search for ways to enable the part to correctly function before proceeding to assemble additional parts or additional units. This might involve:

    a. Checking that the part's dimensions are correct,
    b. Looking for rough spots which could be hanging up the part,
    c. Seeing if there are proper clearances for moving parts, or
    d. Re-visiting the instructions to determine that they have been followed.

2. The best approach we can advise is to assemble as much of the toy as possible without gluing, that is, dry assemble the toy. This approach has been suggested in most of the toy building chapters. If the parts that are to be glued are fitting properly, the toy should hold together without glue in order to test that its moving parts are working properly.

3. Take precautions before assembling, such as, reaming out holes that might have gotten sealer, paint, or clear finish in them.

4. If making multiple copies of a toy, test any jigs that are being used after making two or three toys to determine that you are getting good results, before making a large batch of the same toy.

In putting together the instructions for making the 15 toys in Chapters 3 – 17, we have tried to insert warnings or suggestions that will prevent problems from occuring. We hope these have helped and that you find success in constructing wooden toys.

Appendix

Some Suppliers of Wooden Toy Parts

A search of the internet will provide a number of suppliers of wooden toy parts. Following are few that appear to have a wide range of parts. Check the web pages of these and others firms to compare costs and sizes of the parts you need.

American Woodcrafters Supply

Armor Crafts

California Dowels and Turnings, Inc.

Casey's Wood Products, Inc.

Woodworks Ltd.

Some Other Books on Making Wooden Toys

Here is a small selection of the many books on toy building that have been produced over the years. Noted are special features of these books.

Makowicki, Jim. Making Heirloom Toys. The Taunton Press, 1996.
Features transportation toys (cars, trains, trolleys, planes and boats).

Nelson, John R., Jr. American Folk Toys. The Taunton Press, 1998.
Includes a wide variety of toys made years ago that can still delight children of all ages today.

Wakefield, David. Animated Animal Toys in Wood. Fox Chapel Publishing, 2014.
Contains lots of good tips for making animals that move.

Decimal Sizes of Selected Drill Bits

Lettered Drills		Fractional drills		Millimeter drills	
Letter	Size (inches)	Fraction	Size (inches)	Millimeter	Size (inches)
A	0.234	15/64	0.234	6	0.236
B	0.238				
C	0.242				
D	0.246				
E	0.250	1/4	0.250		
F	0.257				
G	0.261				
H	0.266	17/64	0.266		
I	0.272				
J	0.277			7	0.276
K	0.281	9/32	0.281		
L	0.290				
M	0.295	19/64	0.297		
N	0.302				
O	0.316	5/16	0.312	8	0.315
P	0.323				
Q	0.332	21/64	0.328		
R	0.339				
S	0.348	11/32	0.344		
T	0.358	23/64	0.359	9	0.354
U	0.368				
V	0.377	3/8	0.375		
W	0.386	25/64	0.391		
X	0.397			10	0.394
Y	0.404	13/32	0.406		
Z	0.413				
		27/64	0.422		
				11	0.433
				12	0.472
				13	0.512

The Authors and Illustrator

Charlie Bierman. After serving in the Army during World War II, Bierman earned a degree in engineering. He was employed in the aerospace industry and worked for many years on the launches of the Atlas rockets. After retiring he took up woodworking, and this led to toy building. He was the leader of the El Cajon, California toy making group for over 20 years.

Charlie Pinkus. An undergraduate degree in industrial engineering led Pinkus to pursue graduate degrees in operations research. On completing his studies, he taught in departments of engineering, mathematics, and technology and operations management for 35 years. On retiring he took some woodworking courses, one of which was on toy building taught by Charlie Bierman.

Steve Naiman. Naiman spent over 25 years teaching woodshop to junior high school students in El Cajon. After retiring it was natural for him to continue woodworking and he joined the toy making group in El Cajon. He is now leader of the group and once again teaching woodworking, but this time to seniors.

Bill White. White had a 22-year career in the Navy, from which he retired as a Lieutenant Commander. He always had an interest in woodworking, so after retirement he became head carpenter in the La Mesa/Spring Valley School District. On retiring from his second career he joined the El Cajon toy making group.