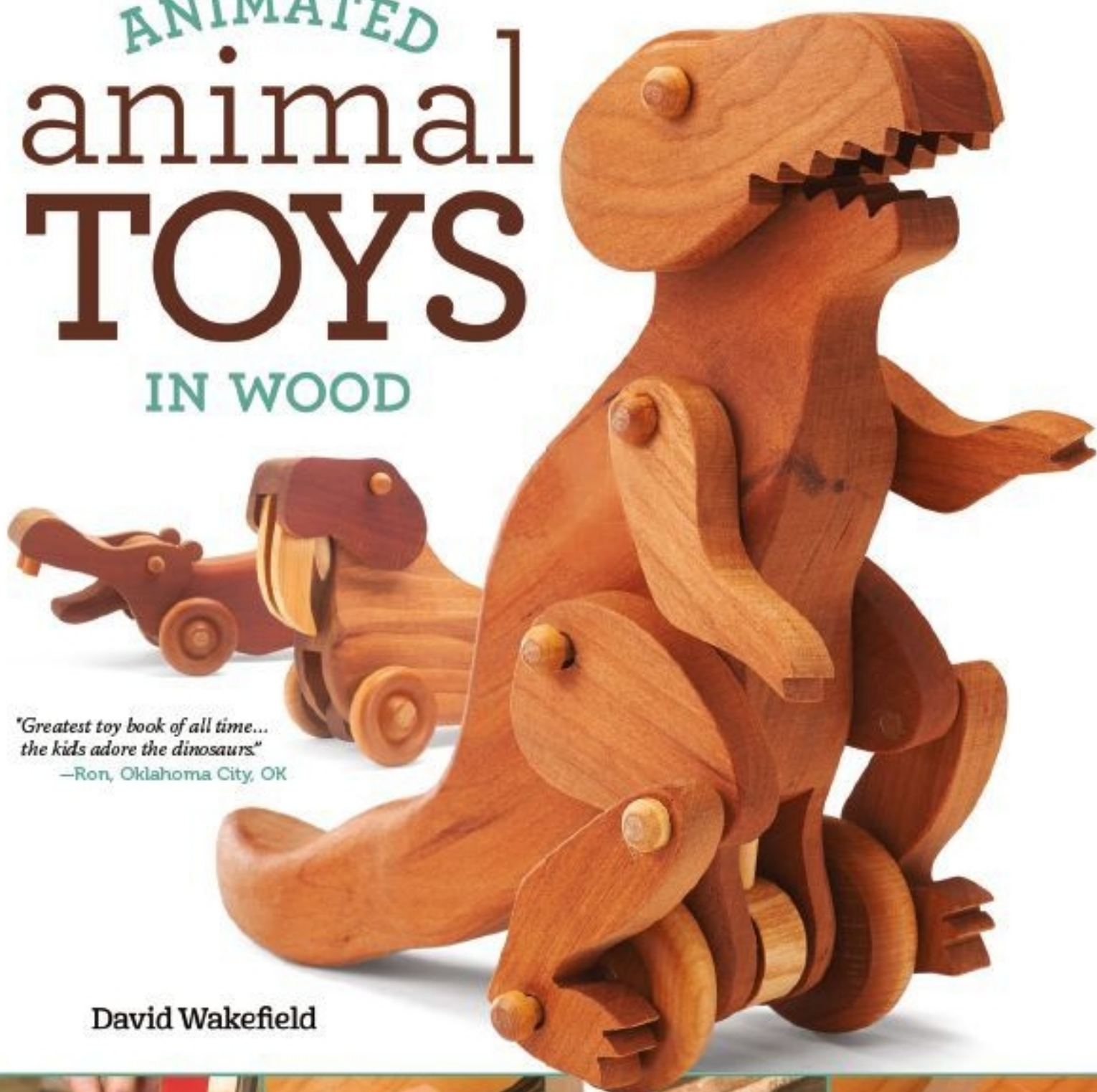


ANIMATED
animal
TOYS
IN WOOD



*"Greatest toy book of all time...
the kids adore the dinosaurs"*

—Ron, Oklahoma City, OK

David Wakefield



20 Projects that Walk, Wobble & Roll

ANIMATED
animal
TOYS
IN WOOD



For my sons, Travers and Leif, who
always remind me what love is.

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From Russia with love

Puika

A child's hand is shown pulling a green rope that is attached to a wooden squirrel toy. The squirrel is made of dark wood with a lighter wood belly and wheels. It is on a light-colored wooden floor. The background is a light blue wall with a white baseboard.

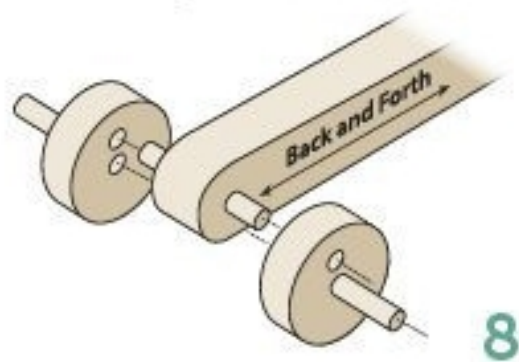
ANIMATED
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20 Projects that Walk, Wobble & Roll

David Wakefield

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Designing Animated Toys

This is a book of toy designs. I've published them for your pleasure—it's my hope that you'll take joy in making them and giving them to your friends and family. For most of you that will be enough, but some of you will find making toys so rewarding that you'll want to design your own toys. A few may even wish to pursue toy making as a profession.

As a toy designer—amateur or professional—one of the first things you'll learn is the value of good design. Design is the essence of this business; anyone can purchase woodworking tools, but not everyone can come up with a good design for a wooden toy. I can't give you concrete instructions for designing, as if I were explaining a toy-making technique or laying out a blueprint, but I can give you a glimpse of how I work out a design for the first time.

A brief aside for budding professionals...as I said, toy designs are valuable. Once you come up with a design that sells well, I strongly suggest that you copyright it. All the designs in this book are my copyrighted property, and as such they cannot be reproduced by anyone else for sale or profit. The law allows the readers of this book to make my toys for their own enjoyment or for gifts, but the toys cannot be sold without my permission—even for the benefit of a church or other non-profit organization. Protect your designs in the same way. See the appendix for the address of the Library of Congress and contact them for the proper forms. It costs a few dollars to register each design, but it's well worth the investment.

Elements of Design

So, where do you start with ideas for toy designs? Well, the best way to start is by looking around you. Is there an animal that you're particularly fond of? Or is there some kind of plane, car, or boat that you'd like to make into a toy? Once you've picked the animal or vehicle, think about its appealing characteristics and what movement it has that you can capture in wood. This is the fundamental skill of toy designing: how to convey the character of things through line and movement.

Let's take an example. Say you like butterflies. What is it about butterflies that makes them attractive? The form and color of the wings would probably come to mind first, followed closely by their fluttering movement. These two elements will become the focus of your design efforts. Another example would be a woodpecker (which is my next design). Most people would immediately think of the head and beak going forward and back, and the pileated woodpecker would bring to mind distinctive black, white, and red coloring. So you would try to include both of these features in your design.

Now, how do you actually work out the design? The first thing I do is go online and look at Google images. In five minutes you can have twenty versions of the side view of a pileated woodpecker. I always start with the silhouette that includes all the important features I'm trying to capture. These silhouettes should either be accurate or somewhat exaggerated to emphasize the character

of the animal or machine. For example, look at the downturned mouth and protruding eye of the Friendly Frog (see page 50) or the big nose and ears of the Happy Hound (see page 138). I will spend hours on one silhouette until I think I've captured what I feel is the spirit of the animal.

How Do I Make It Move?

After you've worked out a rough silhouette, decide what type of movement is appropriate for the animal or machine. There are several different ways you can make a toy move.

Rolling wheels

The easiest toys to design are those that simply roll along. Any shape you care to design can be made to roll by adding two axles and four wheels. There's no limit to the number of things that can be made into toys by simply cutting out a silhouette and adding wheels.



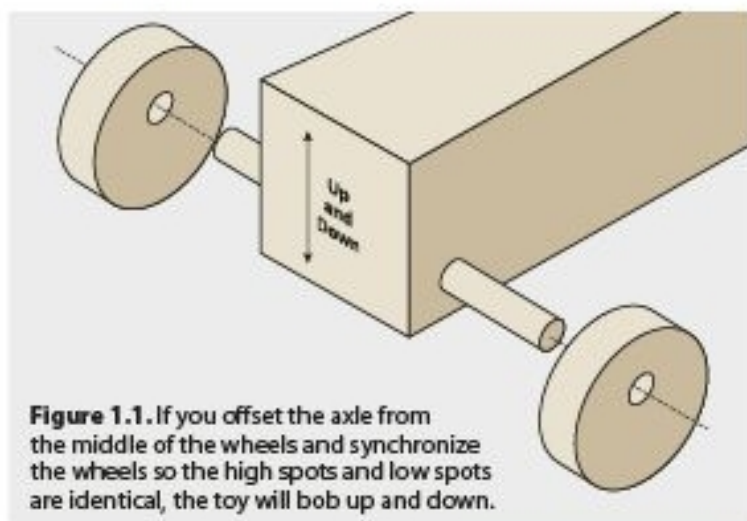


Figure 1.1. If you offset the axle from the middle of the wheels and synchronize the wheels so the high spots and low spots are identical, the toy will bob up and down.

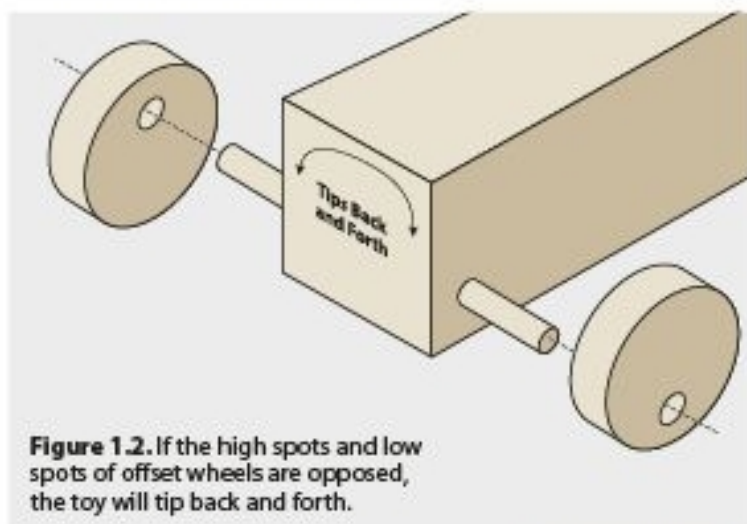


Figure 1.2. If the high spots and low spots of offset wheels are opposed, the toy will tip back and forth.

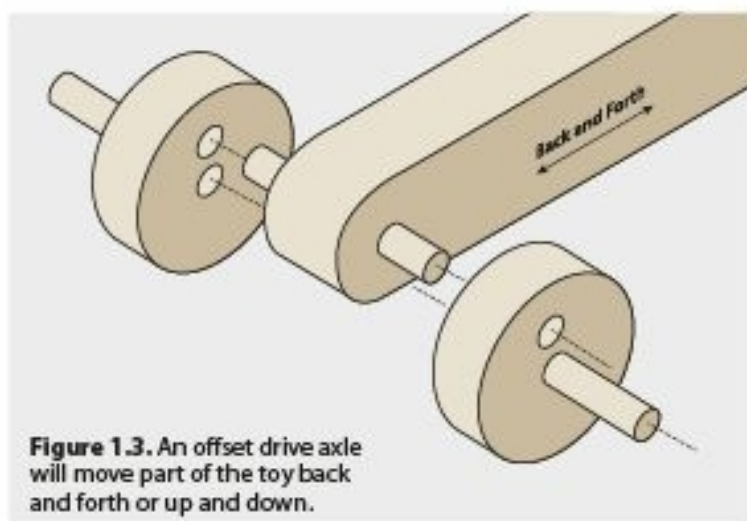


Figure 1.3. An offset drive axle will move part of the toy back and forth or up and down.

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Synchronized offset wheels

The easiest deviation from the simple rolling toy is to offset the axle in the wheels. To do this, plug the center of the wheels and drill new axle holes slightly off center. When the wheels are glued onto the axle and set perfectly in sync with each other (both wheels up or down), they will lift the toy up and drop it down as it is pulled along. This is a great mechanism for anything that you want to make jump or bob (see Figure 1.1).

Opposed offset wheels

This method of movement is similar to the synchronized offset wheels, but the wheels are opposed (one wheel up and the other down) so the toy tips to one side and then the other, as does the *Swaggering Seal* (see page 62) or the *Dexterous Duck* (see page 68). It makes the toy waddle (see Figure 1.2). In some cases, this type of toy may require a central wheel as a pivot while the two outside wheels tip the toy back and forth.

Offset drive axle

This mechanism lets the toy roll evenly while the drive axle lifts or pushes something. The *Timid Turtle* (see page 126) is a good example of this setup. This wheel-and-axle configuration generally needs a hollow area inside the toy to house the offset drive axle (see Figure 1.3).

Outside wheel peg

This setup is a good way to make legs and other parts move. I used this mechanism in the Happy Hound (see page 138) and the Friendly Frog (see page 50). Usually, the part that moves is attached to the peg by the peg head (see Figure 1.4). Bear in mind that the part must be able to make a full revolution without touching the ground or any other part of the toy.

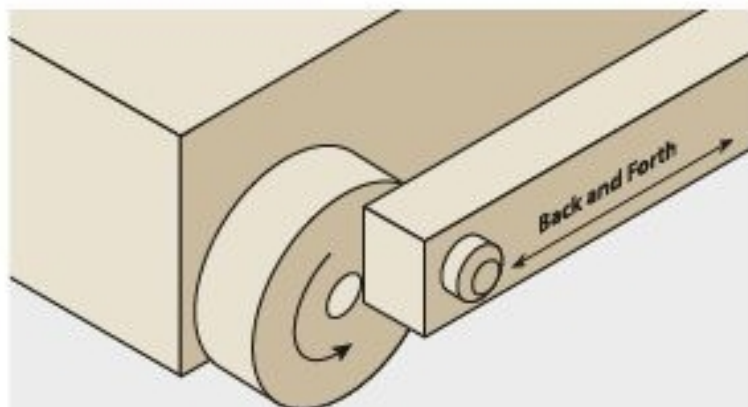


Figure 1.4 If you attach a part of a toy to a peg on the outside of a wheel, it will move back and forth.

Inside wheel peg

In this mechanism, the peg is often hidden, making the action mysterious (see Figure 1.5). For example, see the Loco Lobster (page 114). With the peg mounted on the inside of the wheel, the distance between the pivot point on the moving part and the edge being pushed is critical. Ensure the peg can indeed lift the part without too much force; making the part lightweight will help. Also ensure the part doesn't move so far that it doesn't fall back down again.

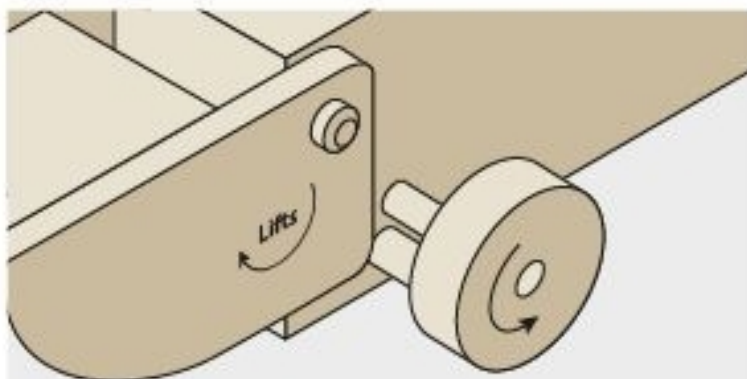


Figure 1.5 A peg on the inside of a wheel can be used to lift a part of the toy. The part will fall back into place after the peg has rotated out of the way.

Simple cam

A cam on the axle raises parts up and lets them fall again (see the Busy Beaver, page 56). It usually requires cutting a slot or dado under the toy with a dado cutter or chiseling out the material (see Figure 1.6). The cam is just an offset wheel that doesn't touch the ground. Cut it out with a circle cutter, plug the axle hole, and drill a new one off center. The cam can be any width, depending on the application. Peg the cam to the axle with a $\frac{1}{8}$ " (3mm) dowel to prevent it from slipping on the axle.

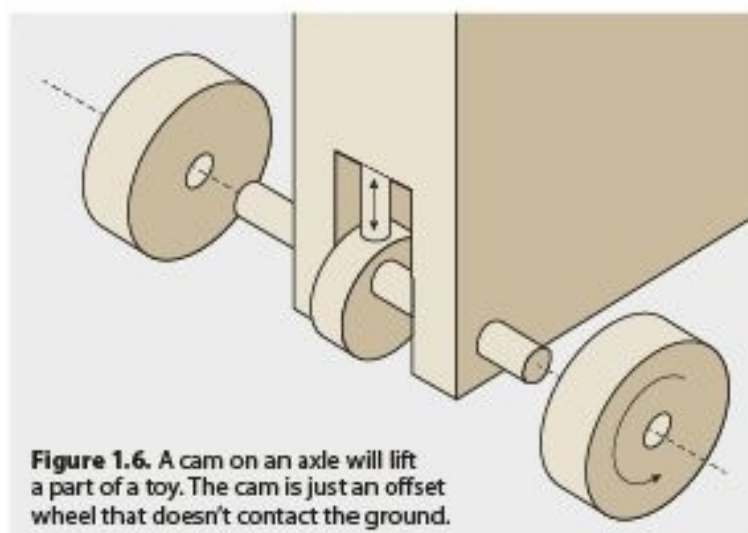


Figure 1.6 A cam on an axle will lift a part of a toy. The cam is just an offset wheel that doesn't contact the ground.

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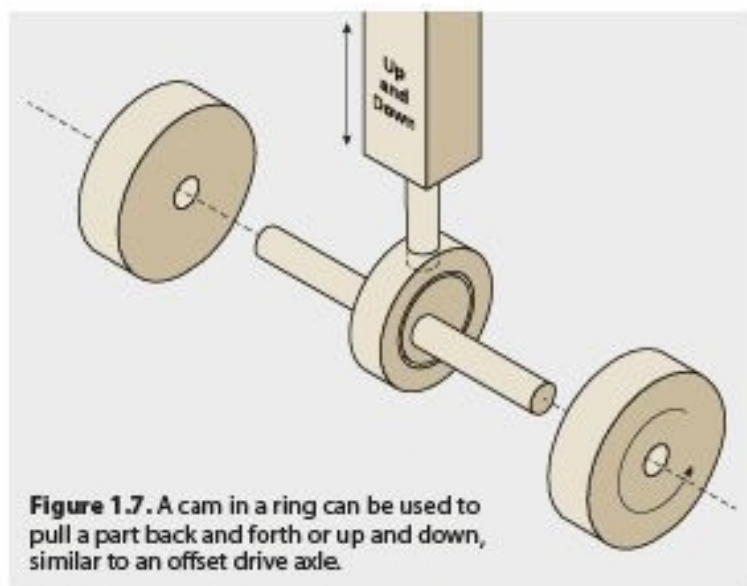


Figure 1.7. A cam in a ring can be used to pull a part back and forth or up and down, similar to an offset drive axle.

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Cam in ring

This combination of a cam and the offset drive axle produces the same type of motion as the simple cam, but it eliminates many of the disadvantages. It requires less space than the offset drive axle, and, unlike the cam, it will move a part through an entire stroke without the help of gravity (see Figure 1.7). When making this mechanism, the outside diameter of the ring should be $\frac{5}{8}$ " (1.6cm) larger than the cam. Drill a hole in the center of the ring that's $\frac{1}{16}$ " (2mm) larger than the cam, and drill an offset axle hole in the cam. Holding the ring perpendicular to the drill press, drill a hole in the outside diameter so that you can attach the moving part to the ring. Usually, the axle must be glued to the ring and other parts in place. This connection makes it impossible to peg the cam to the axle. To help prevent slipping, put some glue grooves on the axle by giving the axle a squeeze with a pair of pliers.

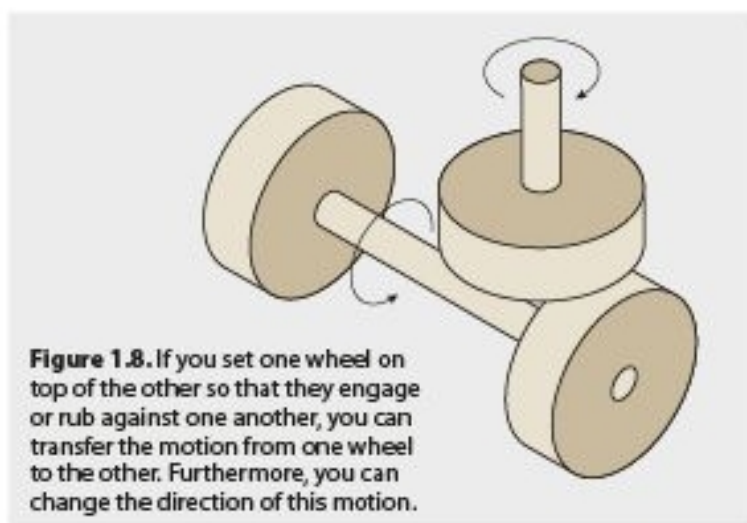


Figure 1.8. If you set one wheel on top of the other so that they engage or rub against one another, you can transfer the motion from one wheel to the other. Furthermore, you can change the direction of this motion.

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Engaged axle and wheel

Make sure you drill the axle hole large enough to let the axle spin freely. Also, position the hole behind and below the top center on the drive wheel (see Figure 1.8). This way the axle will rest firmly on the wheel and the motion of the wheel will tend to lift the axle as it spins it, rather than pushing it down and binding it.

A cam with a yoke

If you make a yoke slightly larger than the cam, it will make a part go back and forth, rotating on a pivot point (see Figure 1.9). The closer the yoke is to the pivot point, the more action will be created.

About Metric

Throughout this book, you'll notice that every measurement is accompanied by a metric equivalent. Because precision is necessary to make these toys, exact equivalents are given. Please be aware that measurements less than 1 centimeter are presented as millimeters.

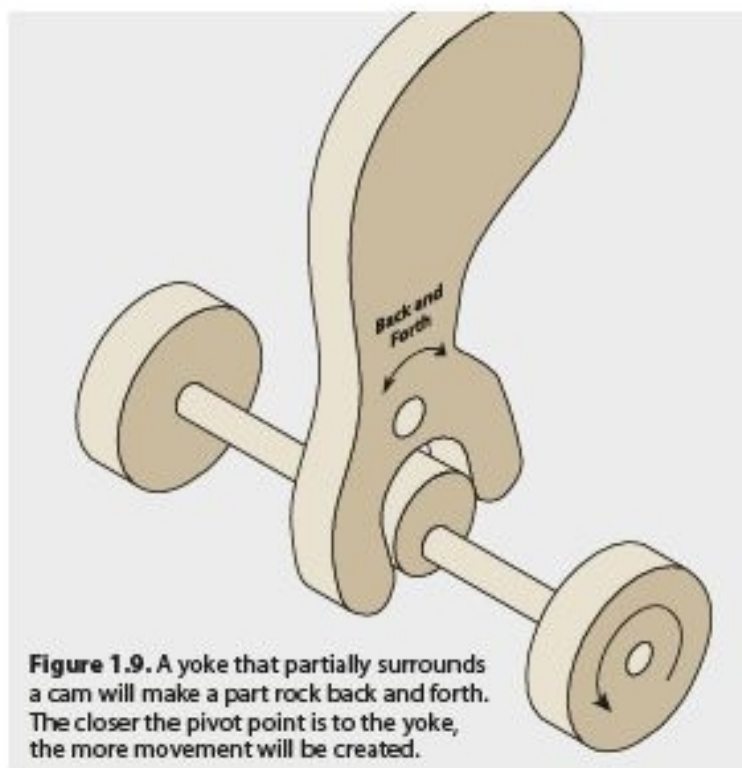


Figure 1.9. A yoke that partially surrounds a cam will make a part rock back and forth. The closer the pivot point is to the yoke, the more movement will be created.

Patterns © David Wakefield

Conclusion

These are just the methods of making toys move that I've managed to discover during my career as a toy maker. I'm sure there are many more that I haven't found yet. Those mechanisms that I have shown here can be combined in many different ways for truly amazing results. An obvious example is the Friendly Frog. The offset wheels lift the body, while the feet (which are pegged to the same wheels) pull the legs up and down. The Friendly Frog (see page 50) really looks as if it is leaping! Or look at the Happy Hound (see page 138). Like the Frog, the Hound's feet are pegged to wheels. But the feet also push against other parts to make the nose and ears move. Half the fun of playing with these toys is tracing the different motions back to

the point of origin and figuring out how everything works together. And all the fun in designing these toys is figuring out how to use or combine these simple mechanisms so that everything works together to produce just the right movements.

All the elements are there for you to experiment with. Don't get discouraged if things don't work out the way you planned on your first attempts. I have an intimate understanding of the phrase, "Back to the drawing board." But I also know that once you perfect a toy design, it gives you a wonderful satisfaction to see it rolling along, magically moving.

So, good luck! This world can use all the delight we can muster.



Materials and Tools

When I first started making toys several years ago, I got my wood from a kiln-drying operation. I bought the rest of my supplies at a local hardware store. In both cases, I paid extremely high prices for materials and tools that were mediocre at best.

In a dogged search for simplicity, economy, and quality, I've located better suppliers. I find my wood closer to home. After I stopped buying kiln-dried lumber, I tried a local solar kiln with cheaper prices. After that, I began air-drying wood from local sawmills. Today, I harvest trees from my land, take the logs to a band saw mill a couple of miles away, and dry the boards in my own kiln.

On the other hand, my search for better materials and tools has led me farther and farther afield. Currently, I use suppliers from Maine to California.

After many years of looking, I've gathered quite a resource list for the toy maker—where to get the best supplies at reasonable prices and tools and materials that can help your work go faster. I've included an abbreviated list in the appendix. Hopefully, this will save you some time and money and get you started on finding your own affordable options.

Of course, I can't guarantee that all the resources I recommend are the highest quality or the least expensive—they're just the best and the most economical that I've found after many years. However, new businesses are always springing up; woodworking companies are always developing new products. If you know of a better tool for a job or a place where you can buy better supplies, by all

means use them. But if you need a place to start looking, use the resources I present here.

I'm also mindful that not all of these resources will be useful to all of my readers. For those of you who only plan to make one or two toys, there's no sense in cutting down a tree and drying your own lumber. For short runs, it's more economical to buy a few boards from a lumberyard. (Better yet, you can probably use the scraps left over from other woodworking projects.) Some "purists" among you will want to make the entire toy—including the wheels and pegs—without buying anything but the wood and the glue. But for those readers who would rather save the time it takes to make these parts, I've found some reliable wheel and peg suppliers (see the appendix). In short, use what you want from this chapter as you need it.

Choosing Wood

I recommend that, in most cases, you use a good grade of hardwood. I'm not a hardwood chauvinist by any means. Softwood is excellent for framing, trim, cabinetry, some furniture, and any number of other uses. Although it is readily available and relatively inexpensive, it is inappropriate for toy making for several reasons. First of all, it splinters easily. This makes it hazardous for children. Second, it isn't strong enough. If you're going to spend long hours making a toy, you don't want it to break the first time a child drops it on the floor. Third, softwoods are so resinous that they will clog sandpaper sheets and belts in no time. And, finally, a finished hardwood toy looks so much better than one made from softwood. You can sand a piece of pine, fir, or spruce all the way down to 400-grit sandpaper and it still won't come near to the beautiful luster and grain patterns of hardwood.

Enough said about softwood. Now, what types of hardwood are appropriate? Several factors are involved. Does it matter whether you use a heavy or a light wood? When you're designing or building a toy with moving parts, weight is an important consideration (see Figure 2.1). In the case of the Loco Lobster (see page 114), you wouldn't want



Hardwoods like Cherry (top), Walnut (middle), and Maple (bottom) will make strong toys that can withstand hours of play.

Comparative Weight and Strength of Hardwoods

Very
Light



Poplar



Aspen



Basswood

Light



Cherry



Walnut



Butternut



Mahogany



Hickory

Heavy



Maple



Birch



Beech



Oak



Ash

Figure 2.1. A quick look at this chart shows that cherry and walnut are the only common hardwoods that are both light and strong. This makes them the best choice for toy making. Of the two, I prefer cherry because it is a little harder and because the dust from walnut is exceptionally toxic and irritating to the sinuses.

**Basswood****Soft****Butternut****Mahogany****Medium****Cherry****Walnut****Maple****Hard****Birch****Beech****Oak****Ash****Hickory**

to make the claws out of oak or hard maple because they would be too heavy to lift easily. But you could make the body out of a heavy wood. This would give the toy stability and the momentum to help lift the claws. If you were making the Friendly Frog (see page 50), you wouldn't want to use Osage orange for the body because it would be too heavy for the eccentric wheel to lift easily. That same wood, however, would be fine for the legs. These parts are so small (compared to the mass of the body) that they wouldn't inhibit the toy's movement.

Weight is something to consider with each toy—and each part. The rule of thumb is that light wood is best for parts that will be lifted. For the rolling or stationary mass of the toy, you can use a heavier wood. Keep in mind, though, that the heavier the wood, the heavier and more awkward the toy will be for a child to play with.

How strong must the wood be? Ironically, the rolling mass of the toy, which can be made from a heavier wood, needn't be as strong as other parts. For example, the shell of the Timid Turtle (see page 126) could be made from strong, heavy woods such as oak or hickory. But it could also be made from mahogany or poplar, which are lighter and not quite as strong. What you make these parts from really depends on your own tastes and the availability of the woods.

The thinner parts, however, must be made from strong woods, especially where there are holes near the edges of pieces. Two examples of this are the Friendly Frog's feet (see page 50) and the Hungry Hippo's head (see page 44).

You should consider one more thing as you choose your wood. You may have tropical woods in your shop. Many of these will make beautiful toys, but here's a word of caution: many dark tropical woods, such as zebrawood, bubinga, and lacewood have toxic resins. Avoid these woods if you are making a toy for an infant who may chew on it. And if you're making a lot of toys, exposure to the fine sawdust from these toxic woods could cause respiratory problems, skin rashes, and eye irritations. Wear goggles, a face mask, and protective shop clothing while you work.

So what wood do I think is best for toys? Cherry. It's relatively light, quite strong, sands easily, and looks beautiful when finished. I also use walnut

and poplar sometimes. They're not quite as strong as cherry, but they're strong enough for all but the thinnest parts. They also look good when you mix them with cherry in a toy.

Where can I get the wood I need?

As I mentioned before, some of you may simply use the scraps you have around your shop. Others may buy what the local lumberyard carries. Or maybe you're planning to become a professional toy maker and you're looking for a reliable source of reasonably priced hardwoods. Where you get your lumber will depend on any number of factors—what woods are available where you live, how much you want to build, how much you want to pay, and so on.

One thing that makes toy making appealing is that you can start right away without a huge cash outlay for materials. Most of the toys in this book can be made with what you have in your scrap bin. You may not have any 8/4 (2" [5.1cm]-thick) hardwood pieces laying around, but you probably have some small pieces of 3/4 or 4/4 wood that you can laminate to make a board of the proper thickness. There is plenty of room here for imagination. Glue up different woods to make striped stock. (A striped Hippo? Why not!) Give strength to weak woods by sandwiching them between stronger pieces. You can also change the design of the toy to accommodate the wood in your scrap bin. For example, the Friendly Frog (see page 50) can be made out of 5/4 stock. Simply adjust the length of the axles.

You may be just starting out in woodworking and not have any hardwood scraps available. How about that mahogany desk with the broken legs? Or the pallets thrown out behind the factory? Have you noticed that the crates behind the local motorcycle shop are made from unusual Asian woods? All of these things can be recycled to make some beautiful toys.

Another good source of inexpensive hardwood is old barns. I once took down an old corn crib and found the corner posts were walnut, all the diagonal braces and rafters were cherry, and the rest of the structure was white oak. When looking at an old building, keep an eye out for excessive checking, rot, and whether or not the nails have rusted off below the surface. Demolition is hard work, and

you want to be sure that you are going to get some usable lumber for your efforts.

A note of caution: If you use old wood, be extremely careful to remove all nails, screws, and staples. One nail can take a big chip out of jointer knives, dull a band saw blade, or completely ruin a carbide-tooth saw blade. Also, some woods, like white oak, become extremely tough after many years. They will take a toll on your blades, cutters, and knives. I think, though, that the beauty of old, air-dried wood more than compensates for the added trouble of dealing with it.

Surprisingly, the most likely place to get cheap wood is a wood shop! There may be a furniture or cabinet shop near you that throws away scraps that would be excellent for toys. If you use your head, there's no end to the places where you can find hardwoods for little or nothing.

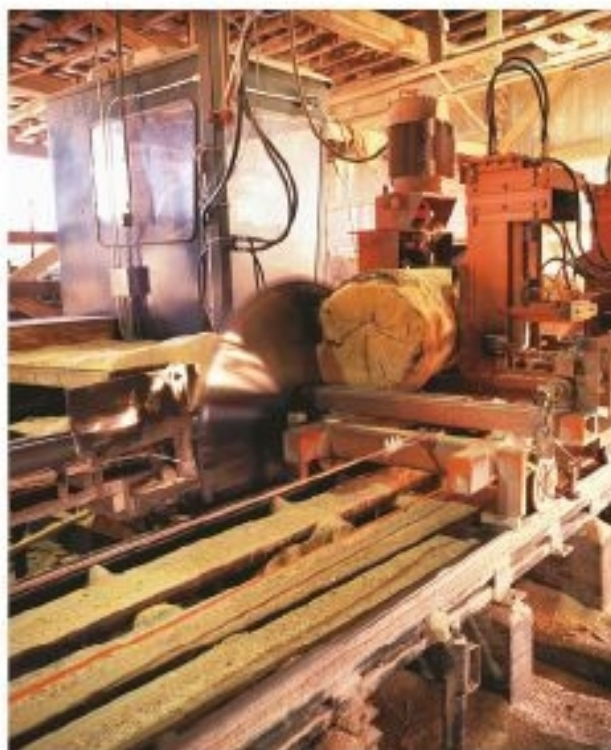
You may be saying, "This is all fine and good, but I don't have the time to browse through dumps or search out discarded woods." Well, most lumberyards have at least a modest selection of hardwoods. These are usually priced quite high because of the limited demand, but remember that a few board feet will go a long way for a toy maker. You can also buy hardwoods (including exotic woods) from Woodcraft Supply (see the appendix). Once again, the prices are high—especially when you add in the freight.

Buying wood in quantity

Suppliers. Some of you are going to make a lot of toys and will need large quantities of reasonably priced wood. If so, there are two avenues open to you. The first is to search out a hardwood supplier. If you live in an area where there are hardwood forests, there will probably be a kiln or a hardwood distributor nearby where you can order lumber. In both cases, you will have to buy somewhere in the neighborhood of 500 board feet to get the best prices.

A note on planing: Some kiln operators and most hardwood distributors will plane your lumber to the desired thickness for a small additional fee.

Sawmills. The other way to get hardwood economically is to go directly to the sawmill. In many states, if you write to the Department of



A local sawmill can be an excellent place to source hardwood. Do some research and try to find those that might sell you 4/4 board or hardwood logs at a reduced rate.

Natural Resources, they will send you a book with all the registered sawmills in the state, listed by county. This book will also tell you the number of board feet each sawmill cuts per year (giving you an idea of the size of the operation) and the services available: planing, resawing, kiln-drying, and so on.

If you live in a rural wooded area, as I do, there will probably be three small, unlisted band saw mills for every large one listed. Look around. Check the phone book. Sometimes these mills will be sawing mostly railroad ties and have stacks of 4/4 board left over. They may sell these cheap to get rid of them. Also, railroad tie and pallet sawmills will often set aside walnut and cherry logs, but won't have the established market to sell the lumber at top prices. You may be able to get some real bargains.

Many sawmills will grade their desirable hardwoods and have low-grade hardwoods that furniture companies don't want. Even though you want to use high-quality wood in your toys, you

can buy #3 grade lumber and simply cut around the knots. If you find a piece of wood with solid knots, you can incorporate these into the toy to give it character. The pieces of wood used in toys are generally so small that the instability caused by knots (which makes the wood unsuitable for furniture) is not a problem with toys.

Kiln-drying. You may have found a sawmill that will supply you with green lumber, and you're considering having it kiln-dried. Or, you may simply be looking for a supplier of kiln-dried hardwood. In either case, you'll want to know the pros and cons about kiln-drying.

The main advantage of kiln-drying is that it's fast. Air-drying wood takes at least a year. In a kiln, however, green wood can be dried in as little as two weeks. Although most kilns will dry only their own wood, you may find one that will dry your lumber. This could enable you to get started working in a matter of weeks.

The other advantage to kiln-drying is that it takes the moisture content a bit lower than air-drying because it drives out the bound water (water held inside the cell walls). This process, however, makes wood "thirsty." Kiln-dried lumber will have a tendency to take on moisture in your shop unless the ends of the boards are painted and you store your lumber in a very dry area, such as a loft or attic. Be careful that the storage area isn't too hot, though, or the ends of the boards may check. There is still some moisture present in kiln-dried lumber (about 7%) that excessive heat can drive out too quickly. However, if you have to choose between a hot storage area and a wet one, take the heat. Changes in humidity are far more destructive to wood than changes in temperature. You can also use a dehumidifier to keep the air dry in your shop.

Kiln-drying has three distinct disadvantages. First, kiln-dried lumber tends to be more brittle. Some woodworkers use air-dried wood exclusively because it has a lively resilience that is lost in kiln-drying. Secondly, drying wood too quickly can cause surface checking and/or case hardening. And finally, the color may be changed slightly. This is especially true of walnut.

Air-drying. The main advantage to air-drying lumber is that you can do it yourself for free. Once you've built a drying rack, your only cost is for

transportation from the sawmill. And you'll find that the price of green lumber at the sawmill is substantially lower than dried lumber from the kiln or the distributor. In some cases, it may be several dollars per board foot lower. This will vary quite a bit, depending on the type of wood and the area of the country, but the savings will be attractive in any case.

Air-drying lumber has three disadvantages as well. The first is that it requires space. Five hundred board feet of lumber will make a stack 4' wide by 8' long by 2½' tall (122 x 244 x 76cm). The second disadvantage is that it takes time. Generally speaking, it takes a year to dry a 4/4 (1" [2.5cm]-thick) board, two and a quarter years for an 8/4 board, and four to five years for a 12/4 board.

The third disadvantage is that air-drying doesn't remove as much moisture from the wood as kiln-drying, and the wood is less stable. I haven't found this to be a problem for toy making, though. The pieces used in toys are usually so small that any movement through shrinking or swelling is negligible. There is also little chance of checking or cracking. Because the pieces are small, internal stresses are released before they build to the point of cracking. I've also found that a mineral oil finish slows down the passage of water enough to prevent rapid changes in moisture content that might otherwise cause checking.

Dowels

For the occasional toy maker, dowels can be found in most hardware stores and lumberyards. The quality and the price will vary dramatically, so shop around. Some dowels are made of soft maple. These are okay, but hard maple and birch are far superior! How do you tell dowels made from softer woods from those made from hard woods? If your thumbnail will easily make a deep mark in the dowel, it's probably soft maple or an imported light tropical wood.

If you're going to make a lot of toys, it's worth ordering dowels from a dowel manufacturer. There are several such companies, but I deal with *craftparts.com* (see appendix). Their dowels are consistently strong, accurately sized, and properly smoothed.



For those of you who want to make lots of toys and will require lots of wood, you can reduce the price by air-drying it yourself. A simple air-drying rack erected outdoors will give you a place to dry green lumber. Add a roof to keep out the rain.



Items like wheels, pegs, and pull handles can be purchased in bulk so you will always have them on hand for your next toy project.

Wheels, Pegs, & Pull Handles

Whether you're planning to build just a few toys or go into production with your own original designs, you should consider buying certain ready-made parts such as wheels, axle pegs, and pull handles. You can turn these parts on a lathe or cut them out with a hole saw, but the process is time consuming. Often, you can buy a better product than you have time to make. I get my wheels, pegs, and pull handles from *craftparts.com* (see the appendix).

If you are going to make your own wheels I suggest a hole saw. You can get all different sizes, although all the toys in this book use 1 $\frac{3}{4}$ " (4.4cm) wheels. You'll find that a hole saw with a 2" (5.1cm) i.d. is just about 1 $\frac{3}{4}$ " (4.4cm) on the inside. I drill most of the way through my

stock and then turn it over to finish the cut. That way I can get a hold of the wheel with vise grips and easily get it out of the hole saw without marring it. Then I carefully edge sand it to get the burr off and remove any burning from the saw blade.

Once you've cut the wheel and sanded the edges, decide how you are going to use the wheel in the toy. If you need an offset axle hole, plug the pilot hole with a small dowel and drill a new hole. If you want a centered axle hole, you'll probably have to ream the pilot hole out. Pilot drills are usually no larger than $\frac{1}{4}$ " (6mm), and often you need a $\frac{5}{16}$ " (8mm) axle hole. Use a twist bit to do the reaming (holding the wheel with vise grips).

Abrasives

There's quite a bit of sanding involved in toy making. You'll find that the right materials make the job go a lot faster. Woodcraft Supply (see appendix) can fill all your sandpaper needs, from sheets to belts.

Finishes

Perhaps the most important consideration when choosing a finish for your toys is that it be nontoxic. Many natural and synthetic finishes are toxic to one degree or another, and this could be harmful to children if they were to chew on the toys.

After thirty-five years of toy making I've settled on mineral oil. I use Crystal Plus 70 FG (see the appendix). The "70" stands for the viscosity. I use the thinnest available so it will soak deep into the wood, offering the most protection. The "FG" stands for food grade. That speaks for itself. Mineral oil is easy to apply (and reapply over time), is nontoxic, and gives the toy a pleasant easy look rather than being shiny and a bit garish like hard finishes.

Color can be a nice touch on some toys. If you plan to paint them I suggest a gloss latex paint. This type of paint is relatively nontoxic and gives the toys a bright, deep hue. You can buy latex paint in quart containers at a paint store, mixed to any color your heart desires.

Some woodworkers use Luma Dye® watercolors to paint woods. Unlike latex, these colors don't coat the wood. They soak in and become transparent, allowing you to still see the wood grain. However, these colors only work well on light-colored woods such as poplar or maple. They are available at most art supply stores. A friend and fellow toy designer has had good results just using RIT dye, which you can get at the supermarket.

For toys intended for older children (nonchewers) and adults, I sometimes finish them in shellac, just for the fun of it. I use spray shellac for ease of application to all the complicated surfaces. Be sure to use a vapor mask when applying any hard finish, whether you are spraying or simply brushing. The fumes will do some serious damage to your sinuses and lungs.



Sheets of sandpaper and sanding belts will be required to help finish and shape the toys as desired.

Glue

The best glue that I've found for toy making is an aliphatic resin glue, commonly called yellow glue. Yellow glue, when it is used properly, sets up to be stronger than the wood it joins. In particular, I use Titebond Wood Glue. Titebond has three formulas now. I still use the original Titebond. Titebond II is faster setting up, which is definitely not an advantage when you are trying to align parts. Titebond III is waterproof, which serves no purpose for these toys, plus it has the distinct disadvantage of being dark in color.

You'll want to watch out for freeze-thaw cycles. You only get about four or five before the glue starts to thicken and lose some of its effectiveness. So it's best to keep the glue and the finished toy in a heated environment. Titebond is also water soluble. It cleans up with a wet rag. And if it becomes too thick, just add a little water and mix it with a paint stirrer.

To use yellow glue, both surfaces of the wood must be clean and free from oil. (Titebond won't hold if the parts have been previously finished (with mineral oil). Spread the glue out evenly, applying extra glue to end grains. The end grains soak up the glue faster than the flat grains, so joints in this area require more glue if they are to bond properly.

Once you've spread the glue properly, clamp the pieces together. This clamping is extremely

important. Glue that cures under pressure is much stronger than glue that is allowed to dry without pressure. But don't apply so much pressure that the clamps squeeze all of the glue out from between the boards. This will result in a starved (weak) joint.

Pull Handles and Cords

I use macramé beads for pull handles. They come in a variety of finishes: natural, stained and varnished, or brightly colored and lacquered. As small children will almost certainly chew on these parts, I recommend you buy the unfinished beads and then finish them yourself with a nontoxic finish. I get mine from *craftparts.com* (see the appendix).

The best cord that I've found for pull toys is acrylic macramé cord. Cotton will fray, but acrylic can be melted at the end so it won't unravel. Just pass the end of the cord past a flame until it begins to shrivel up. This also makes it easier to insert the cords into the toys—the melted ends can be threaded through holes with less frustration than ordinary cut ends. Look for braided cord. Twist cord is not intended for continuous flexing and will eventually lose its twist after extended use. I get my cord from Pepperell Braiding Company, *pepperell.com* (see the appendix).

Hand Tools

There are a few hand tools that you'll need to make toys (see Figure 2.2).

The dovetail saw is used to cut off protruding dowel ends during assembly. It's also useful for taking toys apart to make corrections. The four-in-hand is a combination of a flat and curved rasp for coarse work and a flat and curved file for smoothing out rough areas. This is an extremely useful hand tool for a variety of shaping and smoothing tasks. I prefer the smaller size (8" [20.3cm]) for most work.

A rat-tail file will come in handy from time to time to smooth tight curves.

You'll need a standard 16-ounce claw hammer. You may think that a rawhide or wooden mallet



I've found yellow glue to be the best for toy making. While Titebond glue comes in several different formulas, I prefer the original.



Figure 2.2. You don't need a lot of hand tools to make toys, just the few basic cutting, pounding, gluing, clamping, and measuring tools shown here.

would be more appropriate for this work; however, a steel hammer is the best. For hammering wheels on axles, you want the metal mass of a hammer to drive them through straight away in just one or two hits. Every time you hit a wheel onto an axle, a little glue squeezes out onto the tool you're hitting it with. Glue can easily be wiped off a metal hammer, but it tends to build up on wood or rawhide. After a time, there is an ugly black mess on the end of your mallet. This, in turn, will leave black marks on the wheels.

In the clamp department, I use mostly the trigger-type clamps, although C-clamps come in handy in tight spots where the larger clamp won't fit. The more clamps the better. Often times, you will have several parts glued up and drying in the clamps when you're ready to glue up something

else. If all your clamps are in use, you'll find yourself waiting for glue to dry.

You'll need a chisel from time to time, but there's no need to buy an entire set. A $\frac{1}{2}$ " (1.3cm) or $\frac{3}{4}$ " (1.9cm) straight chisel will work for most situations.

A coping saw is needed for a few of the toys in this book for cutting out small pieces. You can also use it instead of a band saw for cutting out irregularly shaped parts. This takes a great deal of patience and care, though.

A small square of some sort is essential for marking and for keeping the band saw blades and sanding belts square to their respective work tables.

A scratch awl is useful for marking the center of holes before drilling. You can also use it to mark stock for cutting.



Toy Making Techniques

To the untrained eye, toy making appears to be quite simple. Just cut out a shape, slap on some wheels, and there you are. In actuality, though, making a quality toy demands a fair amount of knowledge, skill, and patience. I don't say this to discourage you, but to encourage you to read this chapter. It will help you to avoid most of the mistakes that I've made (and learned from) during my thirty-five years as a toy maker. In toy making, as in most things, there is a hard way and an easy way. The potential is there for either frustration or satisfaction. I'd like to help you maximize the latter.

Some of you are already skilled woodworkers. Remember, though, that toy making is a specific area of woodworking, and as such it has its own particular problems and solutions. So whether you are a novice woodworker or a skilled cabinetmaker, I believe that the information here will prove invaluable.

Transferring Patterns

No matter how you plan to transfer the patterns onto your wood, the first thing to do is to duplicate the full-size plans so you don't have to damage the book by tearing out the pages. Be sure to press the book flat. I would also measure the finished patterns and compare them with those in the book. Some duplicators will slightly alter the size. In some cases it will be helpful to make at least a couple of copies for things like sets of legs that only show one pattern in the book.

Once you have your pattern pages you can approach this in a couple of different ways. The easiest method is to cut the pattern out and tape it to the wood using see-through tape. Tape the entire perimeter of the pattern so that it stays perfectly flat. Drill the holes first, and then saw it out and discard the paper.

If you want to reuse the patterns, you can tape the patterns to the wood with a piece of carbon paper between them. Carefully trace the pattern with a stylus. A ballpoint pen that's run out of ink makes an excellent stylus. Or you can sand a $\frac{1}{4}$ " (6mm) dowel to a rounded point. Using either instrument, the carbon paper will transfer the pattern to the wood, and you can re-use the pattern innumerable times.

If you tap the hole locations through the pattern with an awl and a hammer, you can remove that pattern after cutting out the silhouette and drill the holes accurately. This will avoid tearing up the patterns by drilling through them.

Using the Band Saw

Once you've transferred the patterns for the toys to the wood, the next step is cutting out the parts. Chances are, the tool that you'll use for this job will be a band saw. (Some of the small parts, however, can be cut out much more safely with a scroll saw or even a coping saw.)

Choosing blades. When cutting on the band saw, I usually use a $\frac{1}{4}$ " (6mm) blade with a pitch of 4 or 6. The pitch refers to the number of teeth per inch. A 6-pitch blade (six teeth per inch) is good for general use. A 4-pitch blade is more suitable for production. I also use a $\frac{1}{8}$ " (3mm) blade with a pitch of ten for cutting tight curves. If the blades that are available have a higher pitch, that's fine. You'll just have to cut a little slower with a high-pitch blade.

Always buy skip-tooth blades. These blades clear the sawdust from the cut more efficiently, and they enable you to cut hardwood more quickly without clogging the blade.

The use of the band saw is pretty straightforward, but there are a few simple tips that you can take advantage of to speed up your work. First of all, always make sure the table is precisely perpendicular to the blade before you begin cutting (unless, of course, you're making angle cuts.) This will save you time and aggravation when you start edge sanding. It will also ensure the mechanisms of the toys will work properly.

The other critical thing about setting up the band saw is the guides. When I set up the band saw

(changing blades), I unplug the saw, and then back off all the guides. I release the tension, remove the old blade, put the new blade on, and set the tension according to the width of the blade. Then, I adjust the tracking so the blade is tracking top dead center without any guides helping to keep it lined up. I hand turn the upper wheel toward me and adjust the angle of the top wheel until I've got it tracking properly. Then, I plug the saw back in and hit the switch on and off again to be sure it tracks well at speed. Then, I adjust the guides.

I start with the roller bearings, getting them so that I can just see daylight between the back of the blade and the roller. This way the wheel does not support the blade until you push the wood against it. Then I bring the blocks as close to the blade as



possible without touching. (They can press against the blade without heating up if you use composite blocks.) They should be as far forward as possible without interfering with the set in the teeth when the blade is pushed back against the roller bearing. Be sure to lock all the adjustments before getting to work.

Follow good safety practices when using this tool. Don't wear jewelry or loose clothing—these can catch in the blade. Use eye protection, and always adjust the upper blade guides so they are never more than $\frac{1}{4}$ " (6mm) above the work. This positioning limits your exposure to the blade. Finally, keep your fingers out of danger. Many band saws have a small, round insert in the worktable, around the blade. These inserts are usually 1" to 2" (2.5 to 5.1cm) in diameter. Treat this insert as if it marked the boundary of a "danger zone," and never let your fingers stray closer to the blade than the edge of the insert. If your band saw doesn't have an insert, paint a red circle on your band saw to remind yourself of the danger. Remember, small parts can be cut just as quickly with a scroll saw or even a coping saw—you don't have to use the band saw for everything.

The other safety rule that I keep in mind is never to push the work toward the blade with my fingers lined up with the blade. If I were to slip I would push my fingers into the blade. So, I always keep my hands out of the path of travel of the blade, even if this means shifting my hand position many times during a cut out procedure.

Cutting dowels

When cutting dowels on the band saw, clamp a scrap block to the rip fence just in front of the blade. This way the individual dowel will not actually be against the fence when it passes by the blade (extreme safety hazard). To cut a specific length, adjust the position of the rip fence, measuring from the scrap block to the blade. I use the miter gauge (set to exactly 90 degrees) to make the cut. Place the end of the dowel against the scrap, hold it down firmly to the work table, and push the miter gauge past the blade. This setup will also work for other small parts, and it can be done with bundles of dowels (see Figure 3.1).

Ripping and resawing

You can also use a scrap block clamped to the fence to help gauge the length of a rip cut. In this case, mount the block to the fence the same distance beyond the cutting edge as the length of the cut. This block will serve as a stop (see Figure 3.2).

Make the cut by feeding the stock forward slowly. Don't feed too fast, or the blade will tend to cup (bend) in the wood and you won't get a straight cut. Repeat as needed—each rip cut will be exactly the same.

You may want to rip stock (on edge) to get it down to a specific thickness. This is called resawing. The procedure for resawing is similar to the one I just outlined; just omit the stop block. If the stock that you need to rip is taller than the rip fence, you'll need to make a taller fence. This is nothing more than two boards, each as long as the table,



Figure 3.1. The scrap clamped to the fence will help you cut several dowels to the same length. The scrap is clamped in front of the blade so the pieces don't bind as they pass the blade.

Figure 3.3. Clamp the makeshift rip fence to the band saw table, making sure it is parallel to the blade. Sometimes internal stresses in a board are released as it is resawn. This can cause the resawn pieces to press together, binding the blade. A small wedge (kerf keeper) pressed into the kerf, beyond the blade, will counteract this tendency.



joined together at right angles and clamped to the band saw table (see Figure 3.3).

When resawing wide boards, it's advisable to use a wider blade— $\frac{3}{8}$ " or $\frac{1}{2}$ " (1 or 1.3cm). Smaller blades want to follow the wood grain, and the cut may not be perfectly straight. However, you can use a $\frac{1}{4}$ " (6mm) blade successfully for resawing if the blade is sharp, the guides are adjusted correctly, and you set the blade tension just a little more taut than normal. Pass the board through as slowly as necessary to keep the blade cutting in a straight line. If you see the blade start to wander, slow down.

Hold the board firmly against the fence in front of the blade as you push it. Don't apply any

pressure against the blade or beyond it; this will bind the blade. Another problem that could cause binding is internal stresses in the board that are released as you resaw. A small wedge between the resawn portions will counteract this (see Figure 3.3). Toward the end of the pass, a push stick will come in handy. I've included a simple design for a push stick that you can make (see Figure 3.4).

If you have trouble keeping the blade straight when you rip or re-saw on the band saw, there are several possible causes: (1) the blade may be dull, (2) the guides may be out of adjustment, (3) you're not holding the board firmly against the fence, (4) you're trying to cut too quickly, or (5) the fence isn't parallel to the blade.



Figure 3.2. Make accurate dead-end lengthwise cuts (like the Walrus's tusks) by clamping a scrap to the fence beyond the blade.

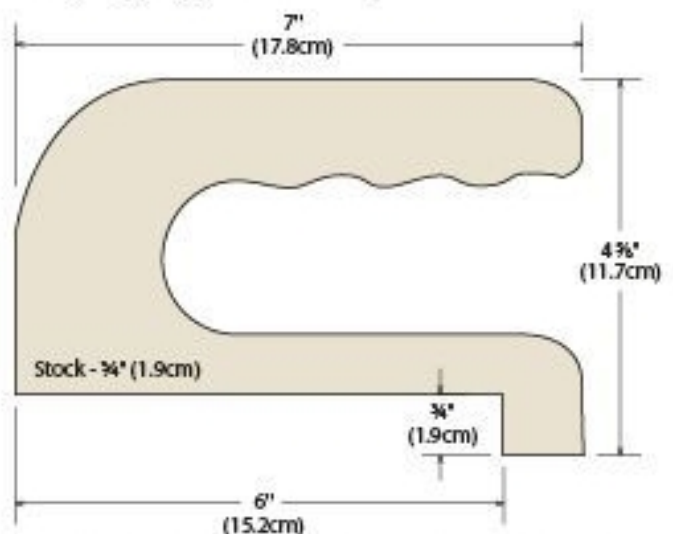


Figure 3.4. A push stick will keep your hand away from the blade during resawing.

Patterns © David Wakefield



Figure 3.5. To cut a peg to length, butt the head against the edge of a scrap of hardboard. Hold it firmly as you pass it by the blade.

Cutting pegs to length

There will be many times when you'll need to cut a number of store-bought pegs to a specific length. To do this, first feed a scrap piece of $\frac{1}{8}$ " (3mm)-thick hardboard into the band saw blade, leaving as much material to the right of the blade as the length of the peg you want to cut. Butt the underside of the head of the peg against the edge of the hardboard. Hold it firmly and slowly pass it by the blade (see Figure 3.5). Repeat as needed, and hand sand the sawn tips to knock off any feathers or burrs.

Cutting tight inside curves

If you need to cut an inside curve that's too tight for the blade you're using, there are a few simple techniques that will help. The easiest is to simply come at the curve from two directions with the cuts meeting at the sharp curve (see Figure 3.6). You can also drill holes of appropriate diameter where

the tight cut will be (see Figure 3.7). Lastly, you can make straight relief cuts that end where the line will make a sharp turn (see Figure 3.8). If you make them perfectly straight you can back out of the cut without turning the saw off, but it's usually better to just be patient, turning the saw off and waiting for the blade to stop moving before you back out of the cut. If it binds at all, you may pull the blade off the wheels as you back out and it might even get kinked, rendering it useless. As you cut out the silhouette, the pieces simply fall away as you get to the relief cut.

There are some instances where you will just have to nibble away at the curve, like the base of the Walrus tusks. Carefully advance the board up to the blade and press it very lightly against the teeth, using the blade as an ultra-thin power rasp. Nibbling usually leaves rough surfaces, but you can clean these up with sandpaper, a drum sander, or a rat-tail file.



Figure 3.6. The simplest way to cut a tight inside curve is to come from both directions. You'll have to turn the saw off and wait for the blade to stop moving between cuts and possibly to get the scrap out after the second cut.



Figure 3.7. Tight inside curves can be cut very accurately by drilling the appropriate diameter hole first.

Cutting tight outside curves

The easiest way to cut tight outside curves is simply to cut until it gets tight and then straighten the cut out and cut off to the edge of the work until the piece releases. Then take up where you left off. The other method is relief cuts as shown in Figure 3.8.

Making do

If you don't have a band saw, a coping saw will do the job with a little muscle and a lot of patience. The trick to using a coping saw is that you have to trace the pattern on both sides of the wood. To get the patterns properly positioned, first trace the pattern on one side of the wood, marking the holes. Drill these holes, turn the piece over, and use the holes to position the pattern on the other side of the work piece. Clamp the stock in a vise and saw out the shape, keeping to the pattern on both sides of the wood.



Figure 3.8. Relief cuts will also help you make tight inside or outside curves. Be sure to turn the saw off and wait for the blade to stop moving before you back out of a cut, or you risk pulling the blade off the wheels.

Using the Drill Press

When using the drill press in making toys, you will find it useful to make several jigs or fixtures to help hold or position the work as you drill. This is done not only for the sake of accuracy, but also for safety. The drill press may not look dangerous; however, any power tool can turn on you if used improperly. When drilling small parts, the work pieces must be supported or held down so that the bit doesn't catch and fling them across the room—or at you. Many of the same rules that I mentioned on the band saw also apply here: don't wear jewelry or loose clothing, use eye protection, and keep your hands clear of the bit.

Preventing tear-out

The first of these jigs is as simple as they get: just a board. When drilling all the way through a work piece, put a board underneath it to keep the back of the hole from splintering out. Any scrap (except particle board) will do. If you're going to drill several holes all the same size, clamp the board down so that it doesn't slip around. If you allow it to slip, the drill will gradually make an enlarged hole in the board. When you drill through the work piece, there won't be enough stock backing up the bit to prevent the tear-out.





Figure 3.9. A dowel in a board will locate wheels accurately for drilling peg holes. If you use raised hub wheels, make a depression for the hubs to sit in as you drill.



Figure 3.10. This simple jig is essential for accurately drilling offset axle holes in wheels.

Drilling offset axle holes

Another essential jig is a board for drilling offset axle holes and peg holes accurately in the wheels. Use a board about 6" (15.2cm) longer than the width of your drill press table. Drill a $\frac{3}{8}$ " (1.6cm) hole, $\frac{1}{16}$ " (2mm) deep, at the center of the board. When you're drilling the inside of a wheel, the protruding axle hub on the outside of the wheel can be set in this shallow hole. This setup will allow the wheel to sit flat on the board.

Drill a $\frac{5}{16}$ " (8mm) hole, $\frac{1}{2}$ " (1.3cm) deep in the center of the $\frac{3}{8}$ " (1.6cm) hole. This hole will support a dowel that will serve as a locating post for the wheels. Cut a $\frac{5}{16}$ " (8mm) dowel long enough so that it will protrude a little bit more than the thickness of the wheel when it is seated in the hole. Sand the diameter of the dowel a bit and round the protruding end so the wheels slip on and off easily, but with no slop. Clamp the board to the table of the drill press so that the drill bit will make a hole precisely the same distance from the center hole each time you put a new wheel in the jig (see Figure 3.9).

Some wheels need to have their axle hole plugged with a dowel, and then a new axle hole drilled just a fraction of an inch off from the original hole. To drill several plugged wheels all precisely the same, cut a V-shaped notch in the edge of a board. Locate this V under the drill bit so that when you cradle a wheel in the V, the bit will make a hole in the wheel that is slightly off center (see Figure 3.10).

A word of warning. I don't recommend that you use a shaper for shaping these toy parts. Most shapers have $\frac{1}{2}$ " (1.3cm) shanks, and the cutters are quite large—too large to do delicate work safely. Routers, on the other hand, take bits with $\frac{1}{4}$ " (6mm) shanks. The cutters are smaller, and they will accommodate smaller work pieces safely.

Making do

Although the router will make short work of your shaping chores, it is also quite easy to do without one. Simply use a four-in-hand rasp or a rat-tail file to break the edges, and then smooth them out with hand sanding.

Using the Table Saw and Jointer

Both of these tools are essential to woodworking in general. You need them to make small, true boards out of large, uneven boards. Other than cutting a dado slot here and there, there are hardly any specific applications to toy making that I need to explain. But I do want to review some safety rules with you.

Because toy making involves so many small parts, sooner or later you'll be tempted to saw or joint a small board. *Don't do it!* Use a band saw or hand saw to cut the piece and a sander or sandpaper to true it up. If you must cut small pieces on the table saw, use a feather board and

push sticks to hold the piece as you feed it into the blade. Never cut anything so small that it might be pinched between the blade and the table insert.

When using the jointer, there is just no way to joint small pieces safely, even if you use push blocks. I use this rule of thumb: if the work piece is less than 12" (30.5cm) long, less than 1" (2.5cm) wide, or less than $\frac{1}{4}$ " (6mm) thick, I true it up on the sander or by hand. Remember that if you should slip when attempting to joint a small part, the rotation of the cutter head will drag your hand down into the machine. That's not a pleasant thought.

Of course, it goes without saying that you should never remove the saw guard or cutter guard to make it easier to work. There are only three operations on the table saw where it's necessary to remove the guard: cutting a dado, a groove, or a rabbet. If you have to remove a tool guard to perform any other toy making operation, you should be using another tool.

Keep your own guard up at all times. Power tools are dangerous; there's no getting around that. It behooves you to develop good safety habits when using them. Don't ever think that safety practices hamper or restrict your woodworking. You'll quickly find that they actually improve the speed and accuracy of your work. They also make you more confident and reduce the stress of working around power tools. All this works together to make your toy making more enjoyable.

Using a Dust Collection System

Whirling bits and cutters are clear and present dangers in woodworking that you can see and hear. Another danger is not quite so readily apparent: sawdust. Not only is dust a nuisance, it can irritate your skin, your eyes, or the linings of your nose and lungs. Several studies have shown that long-term exposure can cause medical problems. Finally, sawdust may work its way into the bearings and bushings of your machinery, dry up the lubrication, and ruin your power tools. For these reasons, if you're going to do any serious toy making, sawdust collection is essential.



I've been using a small shop vacuum for years, along with some simple jigs that I've made to collect dust from my sanders. So much fine dust, however, puts a strain on shop vacs. The dust clogs the filters, causes the vacuum motor to race, and the vacuum wears out in no time.

So instead of relying solely on a shop vac, I've also invested in a small dust collection system. There are many of these on the market, and their prices range from a few hundred dollars on up to thousands. They make several modest systems for small shops that will mount to 30-gallon and 50-gallon drums.

These systems are much more powerful than a vacuum cleaner and will remove almost all the dust that comes off your sanders. With a little ingenuity, you can also hook the system to your band saw, jointer, table saw, radial arm saw, even your router table. I use Masonite and hot glue to fabricate some pretty well-fitted collectors.

Even with the best dust system and well-built collectors there is still dust. It is just inevitable. So, the latest addition to my shop has been a face shield with its own filtered air supply. It's called the AIR/PRO Face Shield, and it's available from *trend-usa.com*. It seals around the face, keeping all the dust out and sends in a clean supply of filtered air. The large face shield enables me to wear reading glasses while I work. It's great and surprisingly light and comfortable (see the appendix).

Gluing and Clamping

There are four different gluing operations in toy making. I'll cover these one at a time.

Gluing flat surfaces together

The surfaces that are to be glued together should be perfectly flat. Any deep planer mill marks or saw marks should be removed before gluing. Using 80-grit sandpaper is sufficient to flatten surfaces that won't be seen after gluing. Experience will teach you how much glue to use. For areas like the top edge of the Hungry Hippo's mouth (see page 44), the squeeze-out doesn't matter. You will either be sanding or sawing that area again, and this will remove the excess glue.

In some areas, however, the squeeze-out is difficult to remove. For example, it would be hard to get the glue off the rear legs of the Happy Hound (see page 138). For places like this, you should put a thin layer of glue on the piece that is to be attached and work it away from the edges toward the center of the piece. This process will minimize squeeze-out.

As you bring the pieces together, be careful to position them properly so that you won't have to move them and expose smeared glue. Before you clamp the pieces, press them together firmly. This will create a suction that will help keep the pieces from shifting when you clamp them.

I use one handed, trigger type clamps almost exclusively at this point. Although they don't apply as much pressure as C-clamps, the pressure is adequate for a good strong joint. This type of clamp has rubber-like pads on the clamp surfaces. But, if you are using C-clamps and the area to be clamped is not going to be sanded again and will be seen, use something to prevent the faces of the clamps from marring the wood. You can use cauls (thin scraps of wood), rubber pads, or you can glue thick pieces of leather to the clamp's faces to avoid the bother of positioning the cauls or pads every time you glue up something.

When you first apply C-clamps, rock them back and forth slightly as you snug them up until the surfaces engage completely. This will help to prevent the work pieces from shifting under the building clamp pressure. It also helps to have the C-clamps set to the proper opening before you apply the glue. Otherwise, the pieces may fall apart while you're fiddling with the C-clamps.

To remove any squeeze-out or smears, wait 20 to 30 minutes after clamping up the parts and work carefully with a chisel or scraper. Generally, I leave the work pieces in the clamps for at least half an hour, and then let them sit for two or three hours before I work with them.

Gluing dowels in place

When you are gluing a dowel all the way through a piece (as in the attachment of the Brawny Brontosaurus's neck to its body [see page 146]), cut the dowel just a little bit long so that it will protrude

slightly from both sides. This way you can sand it flush to the surface after the glue sets up.

To glue the dowel in place, first tap it through the near side and the piece to be attached. Then tap it until it enters the far side. Put waxed paper under your work. Using a wooden matchstick, a toothpick, or a long, thin glue applicator, smear the glue evenly on the inside of the back hole opening and put a little around the exposed dowel on the near side. Here again, experience will tell you how much glue to apply. Lay the part flat on the waxed paper and drive the dowel in place, making sure it protrudes from both sides. A 16-ounce or 20-ounce hammer will provide the concentrated mass you need to drive the dowel easily, without smashing the end of the dowel or splitting it. Wipe off the glue that's been driven out by the dowel on the back side and left by the dowel on the near side. Then let the glue cure. Afterward, sand the dowels flush on the stationary belt sander. Don't sand the dowel too quickly, or you'll burn the tough end grain of the dowel. This will give your toy a "mole."

When you're gluing dowels in a blind hole (such as the dowels that attach the Timid Turtle's head and tail to their respective wheels [see page 126]), be careful not to put too much glue in the dowel hole. This will prevent the dowel from seating properly, and it may make for a weak joint. Use less glue in the hole, and cut several long grooves running down the side of the dowel. These grooves can be pressed in by crimping the dowel with a pair of pliers. The grooves will allow the excess glue to escape from the hole as you drive the dowel in. They will also make for a lot of surface area for a good bond.

Gluing pegs

Gluing pegs in a toy is similar to gluing dowels in a blind hole with one important difference. When you peg a part of a toy to another part, you must leave a tiny clearance between the peg head and the toy. If you leave no clearance, the parts will bind. With practice, you'll be able to leave the proper clearance by instinct. But if you're just beginning to make toys, you'll want to make a clearance gauge. This jig guarantees perfect results every time (see Figure 3.13).

Remember that pegs need to be different lengths for different situations. The length is measured from the bottom of the peg head to the end of the peg. This dimension is determined by the depth of your peg hole, plus the thickness of the part the peg goes through, plus the clearance, minus $\frac{1}{16}$ " to $\frac{1}{2}$ " (0.4 to 1mm) to leave room for glue at the bottom of the hole.

Gluing wheels to axles

When you cut the axles for your toys, double-check the lengths on the bill of materials. The length of an axle is determined by the thickness of the wheels, plus the thickness of the part the axle goes through, plus the clearances needed between the wheels and the part, plus another $\frac{1}{16}$ " to $\frac{1}{8}$ " (2 to 3mm) so the axles will protrude slightly from the wheel hubs when you glue them in place. The axle lengths will change slightly depending on how much you sand the toy parts before you assemble the wheels to the axles.

The glue joint between the axle and the wheel has to be as strong as you can make it. To increase the strength, crimp the ends of the dowel with a pair of pliers. The grooves will allow more glue to stay in the joint when you press the wheels onto the axles.



Figure 3.13. This simple gauge will ensure that pegs are driven in to the proper depth when you are joining pivoting parts.

Some toy makers recommend rubbing the middle of the axle with paraffin to decrease the friction where the axle goes through the toy. This step is not necessary if you build your toys from hard, close-grained woods (such as cherry) as I do. But if you use softer, more fibrous woods, treating the axles with paraffin will help the wheels spin freely and decrease the wear of the axle in the hole. Be careful not to get paraffin on the ends of the dowels where the wheels are glued.

To glue the wheels to the axles, first put a piece of wax paper on the workbench. Put all the wheels on the paper with the insides facing up. Use a matchstick or a long, thin applicator to smear glue evenly inside the holes. Don't apply glue to more wheels than you can glue up in five minutes, or the glue inside the wheels will start to set up and the joints will be weakened.

Drive an axle into a wheel until you feel it hit the workbench. Turn the wheel/axle assembly over and carefully remove any glue that has been driven out of the hole. Give the axle a twist as you press your finger in toward an imaginary point directly above the center of the axle. Your finger will spiral in, lifting the glue off the wheel without smearing it outward from the hub. Now slip the dowel through the axle hole and set the glued-up wheel on the workbench with the axle pointing straight up. Drive the second wheel onto the axle until the axle protrudes slightly from the hub. Remove the excess glue in the same way you did with the first wheel. Wipe the glue off your hammer head and

your finger—I keep a piece of carpet scrap on my workbench just for this purpose. Let the glue cure and sand the axle flush with the hubs of the wheels (on the edge sander).

Gluing assemblies that pivot on pegs

Assemblies that pivot on pegs, such as the Hungry Hippo's head (see page 44), require a simple jig to line up the pivot holes as the pieces are glued together (see Figure 3.14). This jig will ensure that all parts move smoothly when assembled.

To make the jig, square up a block of scrap wood to $1\frac{3}{4}" \times 4" \times 6"$ ($4.4 \times 10.2 \times 15.2\text{cm}$). Stand the block on its end on the drill press table and drill a $\frac{1}{4}"$ (6mm) hole in the end. Cut a $\frac{1}{4}"$ (6mm) dowel 4" (10.2cm) long and round off both ends. Hand sand 3" (7.6cm) of its length until it will easily slip in and out of a $\frac{7}{16}"$ (7mm) pivot hole. Glue the unsanded end of the dowel in the hole in the block. Lastly, cut away the back part of the block as shown in the drawing. This will allow you to clamp the block to your workbench.

To use the block, first fasten it to the bench. (Some of the assemblies may require a scrap block under the jig to raise it to the proper height.) Slip the parts that are to be joined onto the dowel—usually these will be two sides that are joined by a spacer block. Apply glue to the inside surfaces of the sides and position the spacer between them. Carefully bring the whole assembly together with one of the sides pressed against the jig (see Figure 3.15). Press the parts together firmly so they won't shift when

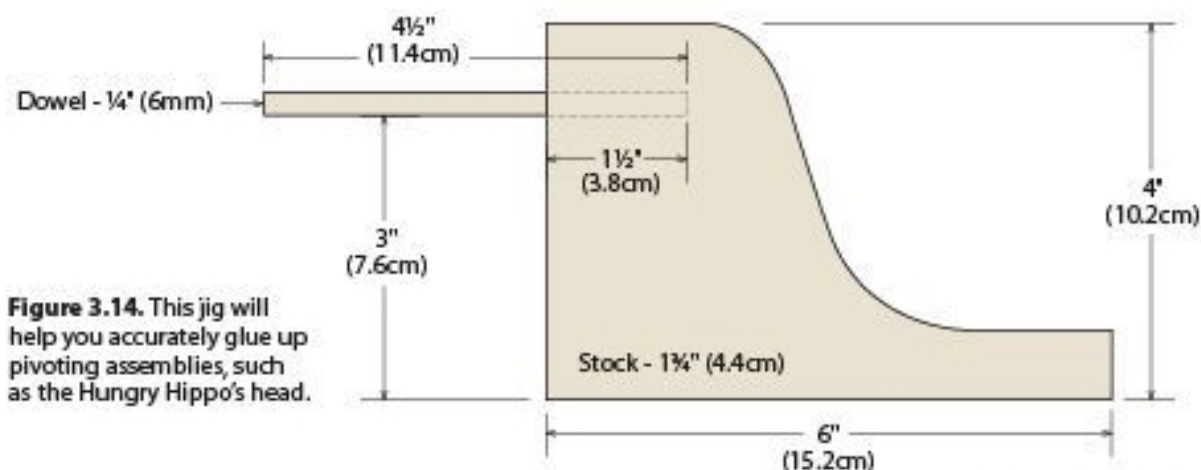


Figure 3.14. This jig will help you accurately glue up pivoting assemblies, such as the Hungry Hippo's head.

Patterns © David Wakefield

you apply the clamps. Clamp the accessible end of the assembly. Then slip the assembly off the jig and apply one or two more clamps, taking care that the parts don't shift (see Figure 3.16).

Hand Sanding

By the time you get to hand sanding a toy, it usually has all its edges and surfaces smoothed already. You only need to do a little touch-up work on the routed edges and the sharp corners. For this reason, I use a scrap of carpet to cushion the toys as I do the final sanding. This way, you can apply as much pressure as you want without fear that you will mar the surfaces that are already smooth.

Because most of the toy's surfaces are already sanded with 120-grit sandpaper at this stage, be careful to only sand those surfaces that need sanding. You can scratch a smooth surface easily when you're hand sanding with 80-grit sandpaper. These scratches will show up prominently when you finish the toy.

To speed up the chore of sanding routed edges, I hold the paper between my thumb and palm, and use all four fingers to apply pressure. This way, you'll get the most cutting action from each stroke. You'll also use more of the paper surface.

Finishing

My finishing preference is food grade mineral oil. I use Crystal Plus 70 FG. You'll find it mentioned in the chapter on materials and again in the appendix, where you can find the address for ordering. I like the fact that it is a nontoxic finish that infants and toddlers can chew on, and it is extremely easy to apply. Over time it will soak deeper into the wood and you may want to apply a second coat, but it is very user friendly.

Finishing one toy at a time

If you're making one toy at a time, the simplest way to finish it is to apply oil with a brush. A brush will reach into all the cracks and crevices with a minimum of effort. Let the oil soak in for a couple of hours and then apply a second coat (and possibly a third). A quick rub with a rag will remove any oil that didn't get completely absorbed.



Figure 3.15. Using the jig to line up the two sides of the assembly, press the three pieces firmly together. Make sure the side next to the jig is flat against it and that the whole assembly can slide freely along the 1/4" (6mm) dowel.



Figure 3.16. Be careful not to let the parts shift as you apply pressure to the clamps. Take the assembly off the jig to apply the second and possibly the third clamp.

Finishing many toys at once

If you're making many toys at once, dipping the toys in oil is the way to go. You'll need to buy at least a 5-gallon container of Crystal Plus 70 FG to do this. Just open the screw-on cap and pour as much finish as you need to cover the toys in a plastic bucket. Then use a funnel to get the remainder back in the 5-gallon container when you're done.

I made a simple trough to drain the toys after dipping, so that the excess oil runs back into the bucket (see Figure 3.17). Put as many toys as you can fit in the bucket. I lay a round piece of plywood, with a lot of $\frac{3}{8}$ " (1cm) holes drilled in it, on top of the toys to keep them submerged. Let them soak for a couple of hours.

Then, I put on some dishwashing gloves and fish the toys out one at a time and put them in the trough. I put first one in the trough next to the bucket, and then I fish out the second toy and push the first toy a little further up the trough to make room for the second, and repeat. This way, most of the excess oil will run back to the bucket by the time a toy reaches the top of the trough. When the trough is filled, let the toys set for an hour or so. After a half hour or so, it's a good idea to flip the toys over. If they started in the trough resting on their wheels, let them set for another half hour with the wheels up. Then put them on a clean surface like cardboard and let the remaining oil soak in.

When almost all of the oil has soaked in, wipe off the excess oil with a rag. You don't have to really rub the toy down. Just wipe off the wet areas. However the type of rag you use is important. Cotton rags, like old T-shirts, make the best rags. They are absorbent and lint free. Synthetic materials don't work well at all.

Painting

In general, I think these toys look best with a clear finish like oil to show off the natural color and grain of the wood. Some toys, however, look much better when painted. For example, if you wanted to make the Dramatic Dimetrodon entirely out of inexpensive wood, you might want to paint the central sail piece a contrasting color from the two finely made sides. At any rate, if you plan to paint your toy, you will want to do that before assembly. This also applies to hard finishes.

Attaching Pull Cords and Handles

Before attaching an acrylic cord to a toy, melt the ends with a match or lighter.

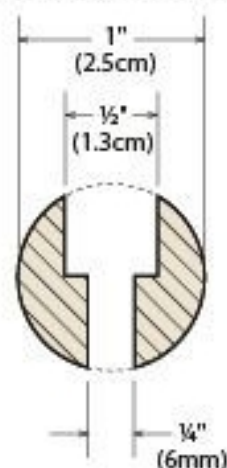
This step prevents the cord from unraveling and helps you to insert the cord in its hole. Hold the cord close enough to the flame that it will begin to shrivel up, but not so close that it catches on fire. (If it does catch on fire, simply blow it out.) Let the end cool; then, while the melted material is still warm and pliable, give the end a twist with your fingers. This will bring the end to a slight taper. (It's a fine line between soft enough to form and hot enough to stick to your fingers and burn. You may want to use cotton gloves to prevent getting burned.)

If you have to thread the cord through a long hole, twist the cord as you feed it into the hole. This twist stiffens and tightens the cord, making it easier to feed through the hole. If this doesn't work, use a nail or awl. Catch the point of the awl behind on the melted tip, and push it through.

When you've threaded the cord through the hole, tie a square knot in one end so that it won't pull out. To hide the knot, drill a countersink for it before you drill the hole for the cord. This countersink is nothing more than a slightly larger hole $\frac{3}{8}$ " to $\frac{1}{2}$ " deep (1cm to 3mm). For example, if you're using $\frac{1}{4}$ " (6mm) cord, drill a $\frac{1}{2}$ " (1.3cm) blind hole for a countersink, then drill a $\frac{1}{4}$ " (6mm) hole through the middle of the $\frac{1}{2}$ " (1.3cm) hole, all the way through the part. Thread the cord through the $\frac{1}{4}$ " (6mm) hole, and pull the knot back into the $\frac{1}{2}$ " (1.3cm) countersink.

Fasten a wooden bead to the other end of the cord in the same fashion to make a handle. You can get these wooden beads with the $\frac{1}{2}$ " (1.3cm) countersink already drilled in one wside from craftparts.com (see the appendix).

1" (2.5cm) Pull Cord Ball



Patterns ©David Wakefield

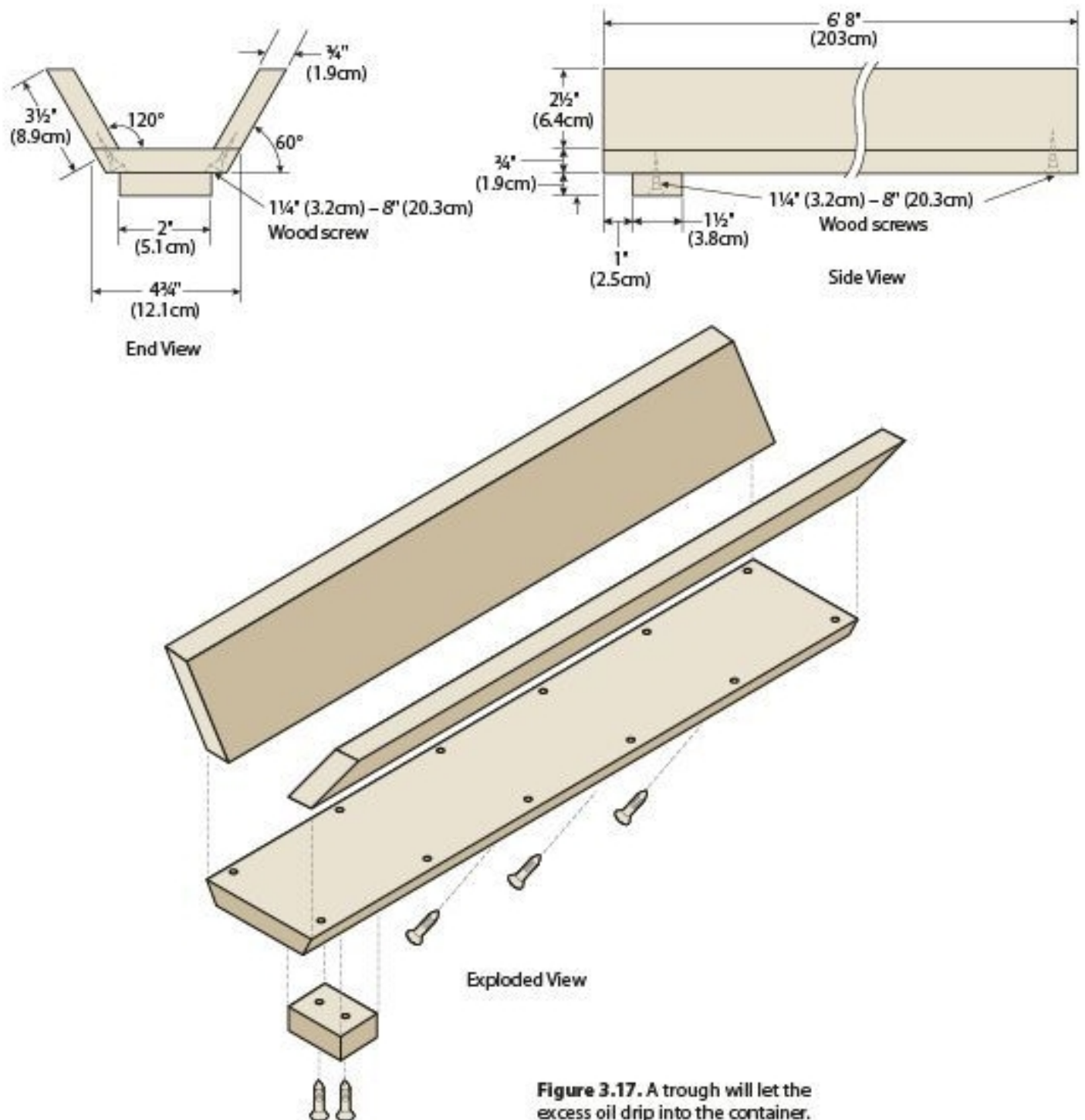


Figure 3.17. A trough will let the excess oil drip into the container.

4 Hungry Hippo

The Hippo's mouth opens and closes with a friendly *chomp* as he's pushed. This movement is accomplished by two $\frac{3}{8}$ " (1cm) dowels that protrude on the inside of each of the front wheels. As the wheels turn, the dowels are alternately pushed against the bottom of the hippo's jaw. The eye pegs act as the pivot of a lever and, as the back of the jaw is pushed down, the front of the jaw is lifted. As the wheel continues to turn, the dowels no longer support the front of the jaw and it falls down with a *chomp*.

The Body

The body of the Hippo can be made out of any species of wood. Transfer the body pattern to a suitable piece of $1\frac{1}{2}$ " (3.8cm) wood. Drill the axle and peg holes. Cut out the shape on the band saw. Edge sand with 80-grit sandpaper. Flat sand with 80-grit and then 120-grit sandpaper. Use a router to shape all the edges; then, edge sand with 120-grit sandpaper. Hand sand all the roughness and router burns with 80-grit sandpaper, and then hand sand all the routed edges with 120-grit sandpaper.

The Head

The head is best made from a strong, light wood. Transfer the pattern of the head sides to $\frac{3}{8}$ " (1cm) stock with the grain running lengthwise. Drill the peg holes. Cut the pieces out just outside the line so you can edge sand them and end up with the exact shape of the pattern. The distance from the eye hole to the bottom of the jaw is critical to the proper opening of the mouth, so drill and cut out these pieces very carefully. Transfer the pattern of the head spacer to a piece of wood $1\frac{1}{2}$ " (4.1cm) thick and cut it out on the band saw. Edge sand the small end and the bottom edge of the jaw spacer (you won't be able to reach them after assembly).

A jig will ensure that the eye holes line up perfectly so that the mouth opens and closes smoothly (see *Toy Making Techniques*, Figures 3.14, 3.15, and 3.16).

Clamp the jig to the edge of the workbench and slide the sides of the head onto the dowel with the ears upward. After applying glue to both flat surfaces of the spacer, spread the sides far enough apart to position the spacer between them without smearing the glue. Now, position the spacer carefully and press the assembly together.

Press the pieces together firmly and make sure (1) that the side piece next to the jig is flat against it and (2) that the whole assembly can still pivot freely on the dowel. After you've made any adjustments necessary, apply a clamp across the assembly with its pressure points on the center of the nose. Be



The Hippo's head rotates up and down on the eye pegs.



The front wheel plugs push on the back of the Hippo's jaw, lifting the head.



The teeth are glued into holes drilled in the bottom of the head spacer.



Figure 4.1. Using the jig to line up the two sides of the assembly, press the three pieces firmly together. Make sure the side next to the jig is flat against it and that the whole assembly can slide freely along the $\frac{1}{4}$ " (6mm) dowel.

careful not to let the assembly shift as you tighten the clamp. Now, slide the assembly off the jig and apply the second clamp at the upper end of the spacer (see Figure 4.1).

When the glue for the head is completely dry (don't rush it), look at how closely the pieces line up. If they're off by more than $\frac{1}{16}$ " (2mm), you should saw off any overhang to save wear and tear on the belt sander. Now, edge sand the head with 80-grit sandpaper. If you glued the pieces accurately, there shouldn't be any problems. Just remember not to take any off the lower end of the jaw or you'll reduce the distance that the mouth will open. Beware when you pass from the area with the spacer to the thin sides alone. There is a tendency to dig in as the thickness is suddenly reduced by $\frac{1}{8}$ " (4.1mm). Use light, smooth passes over these transitional areas.



Figure 4.2. Use a scrap under the Hippo's nose to support it at the proper angle to drill the holes for the teeth.

To drill the teeth holes, rest the nose on a scrap on the drill press so the surface to be drilled is parallel to the drill press table (see Figure 4.2). The clearance between these holes and the edge of the mouth is so small that the holes will split out unless you either drill the holes slightly oversized ($\frac{25}{64}$ " [1cm]) or sand down the teeth until they fit in easily. A Forstner bit will be less likely to split out the sides as you drill.

Before you glue the teeth in, edge sand the head with 120-grit sandpaper and flat sand the sides with 80-grit and 120-grit sandpaper. Hand sand all the edges with 120-grit sandpaper.

Cut the teeth to length and round off both ends by hand sanding. Spread glue (not too much) inside the tooth holes and tap the teeth into place. Do this on a smooth surface to prevent marring the top of the nose.

The Wheels

Use one of the techniques shown in the Toy Making Techniques chapter to drill the offset holes in the front wheels.

Assembly

Put a little glue in each of the eye holes in the body, position the head piece, and tap the eye pegs into place using the clearance gauge (see Toy Making Techniques, Figure 3.13). Glue the back wheels on. Glue the $\frac{3}{8}$ " (1cm) dowels into the front wheels, making sure that they are perpendicular to the wheel's surface (see Figure 4.3).

The front wheels can be positioned in several different ways. Generally, I put the front wheels on with the dowels diagonally opposed so the mouth opens and closes twice for every revolution of the wheels. If, however, the child tends to push toys quickly, you may want to put the pegs directly opposite each other so the mouth will open only once per revolution. This will give the mouth

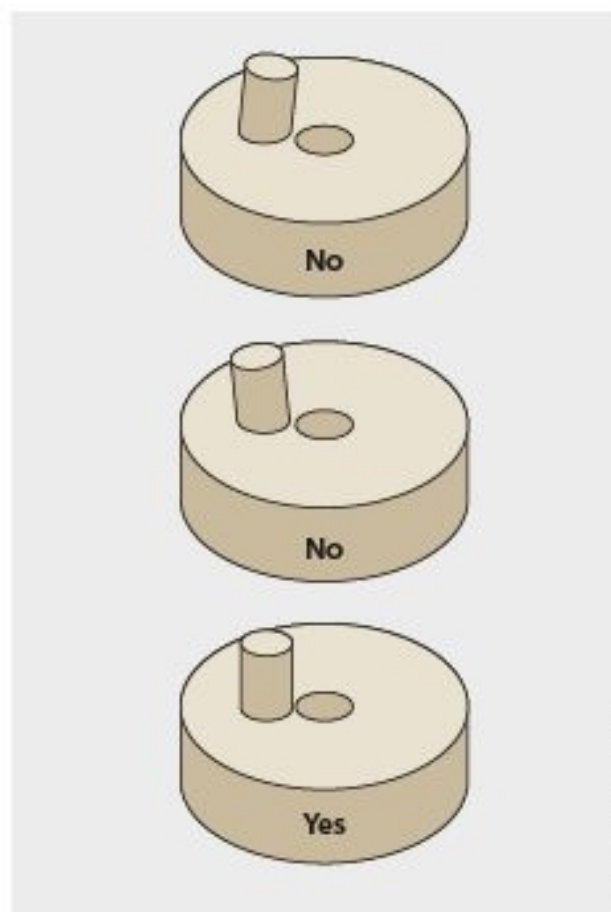
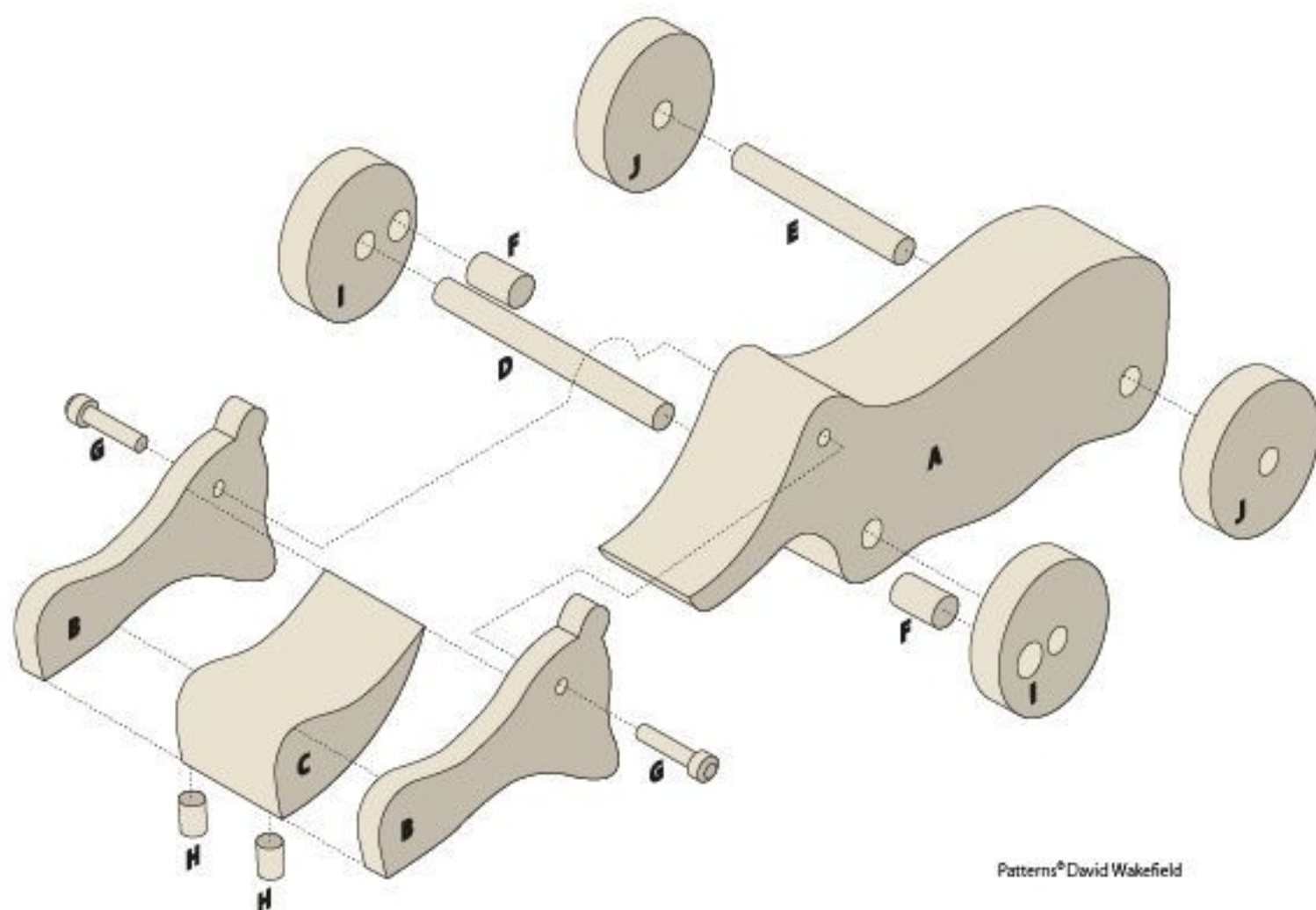


Figure 4.3. Make sure the dowels are glued perpendicular to the inside wheel surface.

time to close completely between chomps. If the child is gentle with toys and sensitive to subtlety, try placing the pegs halfway between diagonally opposed and directly opposite. This will give the Hippo a rhythmic *chomp, chomp...chomp, chomp...chomp, chomp*.

When the glue is dry, edge sand the ends of the axes. Let the glue dry thoroughly and then oil the Hippo. He's ready to go looking for his first meal—or just yawn!

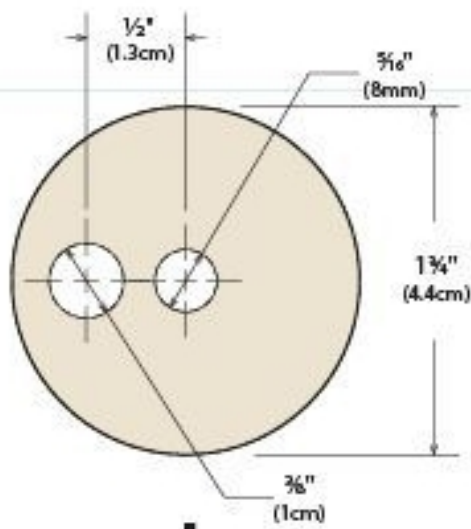
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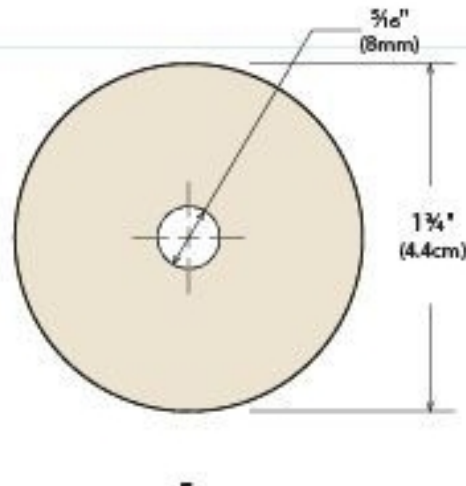
Patterns © David Wakefield

Materials

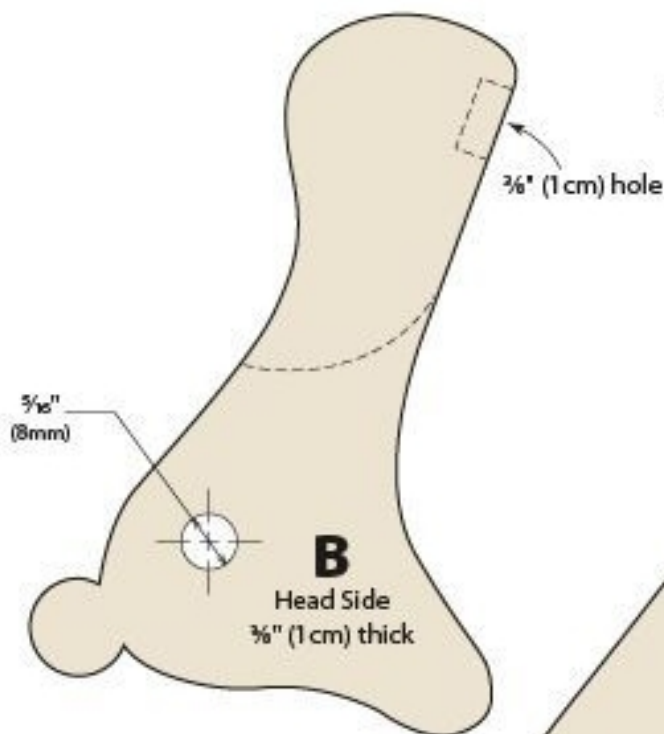
Part	Description	QTY	Thickness	Width or Diameter	Length
A	Body	1	1½" (3.8cm)	3" (7.6cm)	7½" (19.1cm)
B	Head Sides	2	¾" (1cm)	2½" (6.4cm)	3¾" (9.5cm)
C	Head Spacer	1	1½" (4.1cm)	1¼" (3.2cm)	2" (5.1cm)
D	Front Axle	1	—	⅝" (8mm) diameter	3¾" (9.5cm)
E	Rear Axle	1	—	⅝" (8mm) diameter	2⅝" (6.7cm)
F	Wheel Plugs	2	—	¾" (1cm) diameter	⅝" (1.6cm)
G	Eye Pegs	2	—	⅝" (5.5mm) diameter	1⅞" (2.7cm)
H	Teeth	2	—	¾" (1cm) diameter	⅝" (1.6cm)
I	Front Wheels	2	½" (1.3cm)	1¾" (4.4cm) diameter	—
J	Rear Wheels	2	½" (1.3cm)	1¾" (4.4cm) diameter	—



I
Front Wheel - 1/2" (1.3cm) thick



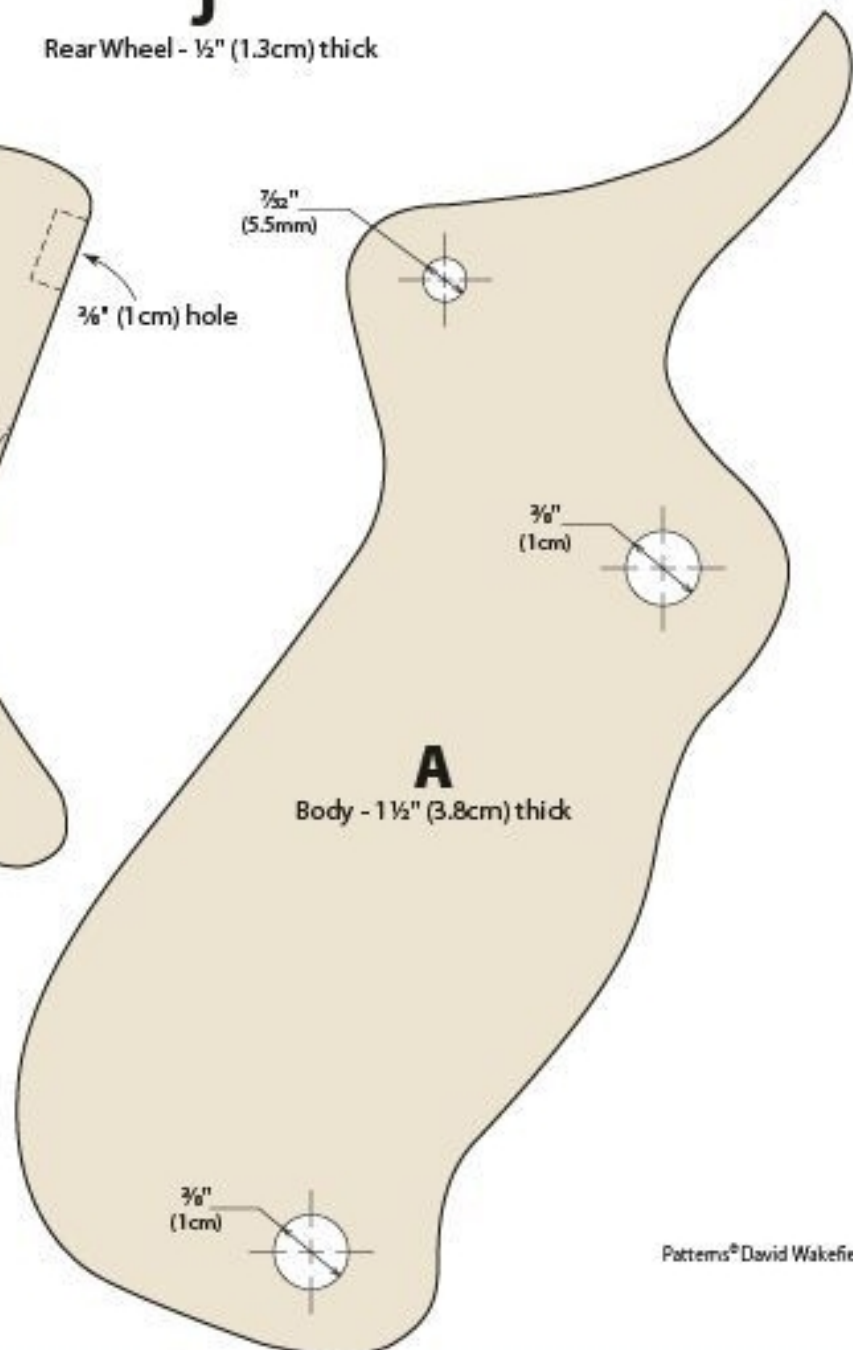
J
Rear Wheel - 1/2" (1.3cm) thick



B
Head Side
3/8" (1cm) thick



C
Head Spacer
1 3/8" (4.1cm) thick



A
Body - 1 1/2" (3.8cm) thick

Patterns © David Wakefield

5 Friendly Frog

This toy is one of my favorites. To my mind, it is the consummate frog, replete with amazing leaps and dour expression. The offset axle in the back actually lifts the body, while the feet, being pegged to the wheels, give the leaps the appropriate leg action.

Like many of the toys in this book and on my website, this fellow was in my first book, but I have reduced him in size by about two-thirds to be, I believe, a little more suitable for small children.

The Body

The Frog's body does not need to be particularly strong, but it should be light to jump smoothly. Transfer the body pattern (A) to a suitable piece of wood. Drill the eye, axle, and peg holes.

Now, cut out the shape of the body. Make several short cuts around the eye to maintain its spherical outline. Be careful not to cut too close to the rear axle hole or you will weaken it.

To drill the pull cord holes, use clamps and/or blocks to hold the body in the proper position on the drill press. Drill the $\frac{1}{2}$ " (1.3cm) hole first and then reposition the body and drill the smaller hole in the chest until it breaks through into the first hole. Now, edge sand the body with 80-grit sandpaper. Sanding around the eye is tricky.

Use the edge of the 1" (2.5cm) belt to cut into the corners behind and in front of the eye (see Figure 5.1). Then gently smooth out the rest of the curve. Take your time. It's details like the eye that give the Frog its convincing appearance. Now, flat sand the sides of the body, use a router to cut the silhouette, and edge sand it with 120-grit sandpaper. Hand sand all the routed edges with 120-grit sandpaper. Don't forget to sand inside the mouth and break the edges of the mouth line (see Figure 5.2).

The Legs

The legs should be made from a strong wood that complements the body. Lay out the legs with the grain running lengthwise. Drill the peg holes, keeping in mind which holes pivot on the pegs ($\frac{1}{2}$ " [7mm] holes) and which holes have the pegs glued into them ($\frac{7}{32}$ " [5.5mm] holes). Be careful to keep to the lines as you cut out the feet. If too much material is left below the foot holes, they may touch the ground as the Frog rolls. This will interfere with the Frog's smooth movement. If you remove too much material, the area will be weak. Keep this in



The Frog's legs rotate up and down on the pegs.



Attaching the leg to an off-center hole in the wheel causes the leg to move up and down as the wheel turns.



The pull cord is attached using the holes drilled through the Frog's body.



Figure 5.1. Use the edge of the 1" (2.5cm) belt sander to sand the tight corners around the eye. Be careful to maintain the spherical outline of the eye.

mind as you edge sand the leg parts with 80-grit and 120-grit sandpaper.

Flat sand the legs with 80-grit and 120-grit sandpaper. This is a delicate operation. Hold the legs firmly, one at a time, with your fingertips so that the tips of your fingers don't touch the belt. This may seem crazy if you are new to the belt sander, but with time, it will become quite easy. A little moisture (spit) on the fingertips will help you grip the wood. If this idea makes you uncomfortable, you can easily sand these small parts by rubbing them back and forth on sandpaper on the workbench. With 120-grit sandpaper, break the edges by hand.

The Wheels

Plug the original axle holes, and, when the glue is dry, sand off the dowel ends the same way you flat sanded the legs.

Drill the offset axle holes and peg holes in the back wheels.

Assembly

Cut the two axles to length, leaving them slightly oversized. Glue on the back wheels, being sure to line up the peg holes so that they are directly opposite each other. Inspect the alignment of the back wheels carefully before the glue sets up and

make any necessary adjustments. When the glue is dry, edge sand the axle ends flush to the hub or inner surface of the wheel, depending which way you decide to face the wheels. I think the offset axle looks better (on the rear wheels) with the inner surface of the wheels facing out. It makes them smooth looking.

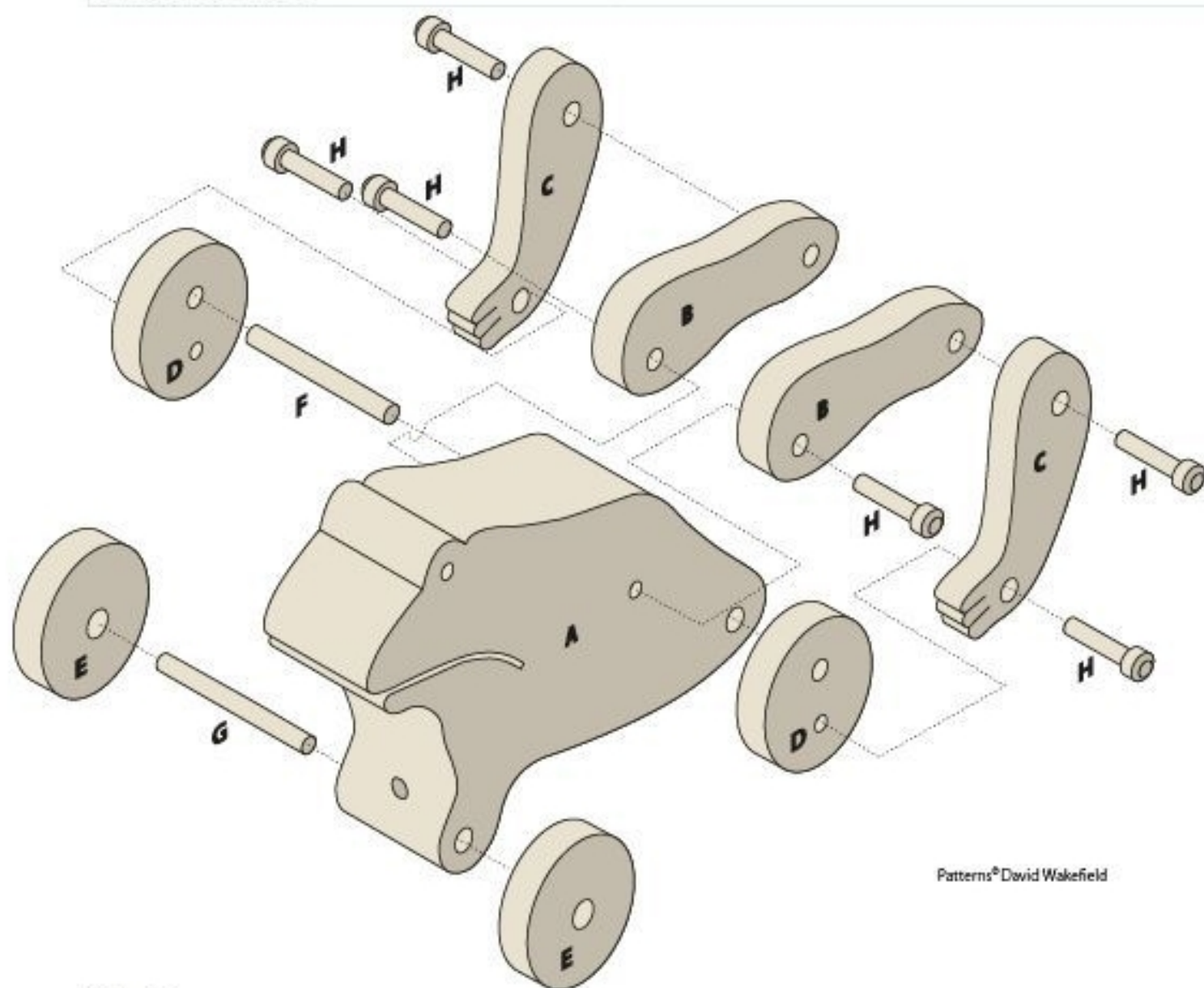
The next step is to assemble the legs. Before you glue the legs together, lay them out on the workbench to make sure that you are making two opposite sets. Put a little glue in the thigh peg hole, slip a peg through the foot piece, and tap it into the bottom of the thigh piece. A clearance gauge is handy here (see *Toy Making Techniques*, Figure 3.13). Repeat this process for the second leg. When the glue has set up, sand off the protruding ends of the pegs and any excess glue using the belt sander or a sheet of sandpaper.

Now, glue and fasten the legs to the body, again using the clearance gauge. Next, peg each foot, one at a time, to its respective wheel. Put a little glue in the wheel hole. Hold the Frog so that the wheel is supported by the edge of the workbench. Tap the peg in place using the clearance gauge to finish the job. Carefully wipe the excess glue off the back of the wheel before it gets smeared on the body. Glue and peg the second foot.

When the glue has thoroughly set up, your Frog is ready to oil. When the oil is dry, attach the pull cord (see page 64) and there you are—one more Frog on the loose.



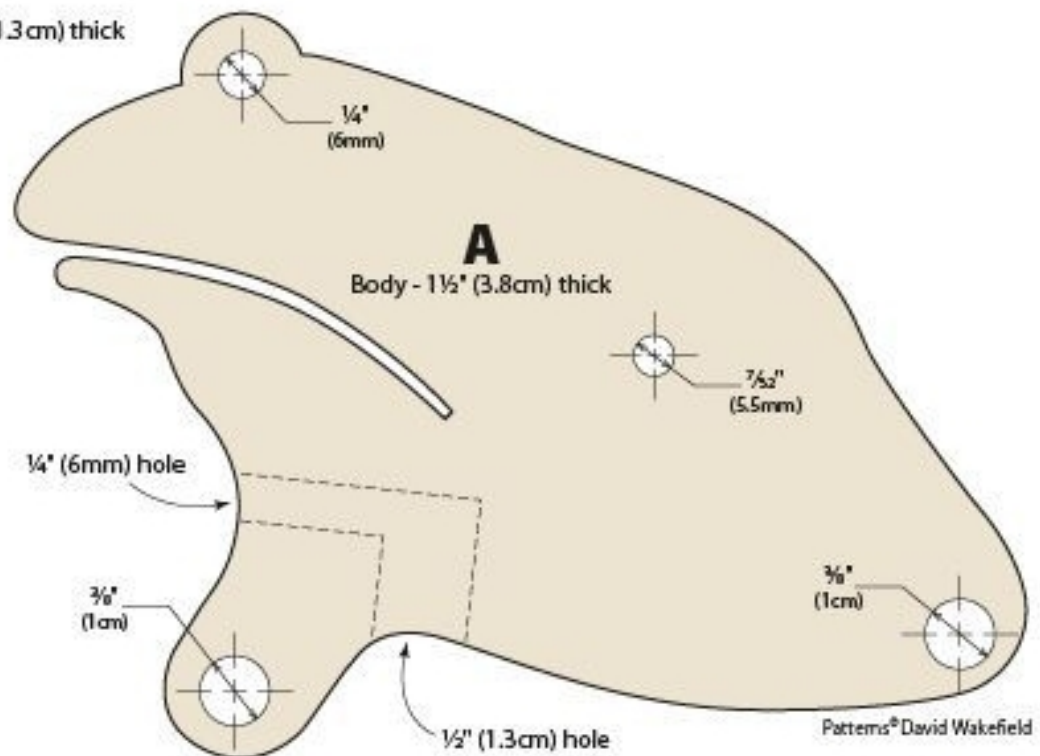
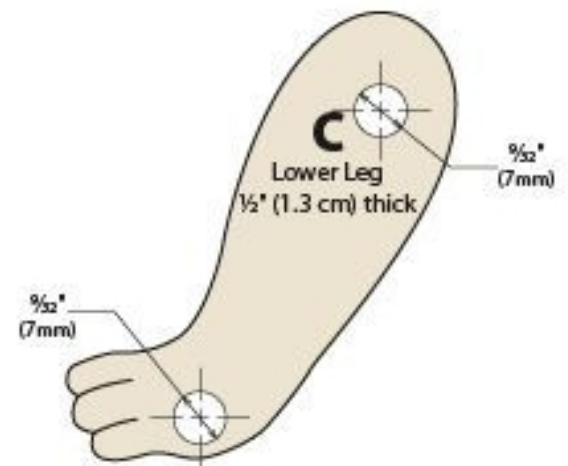
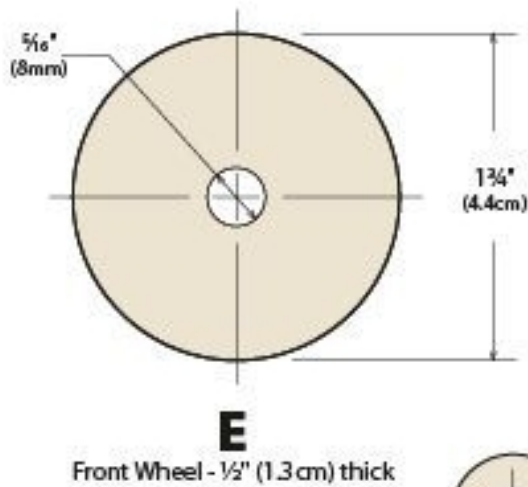
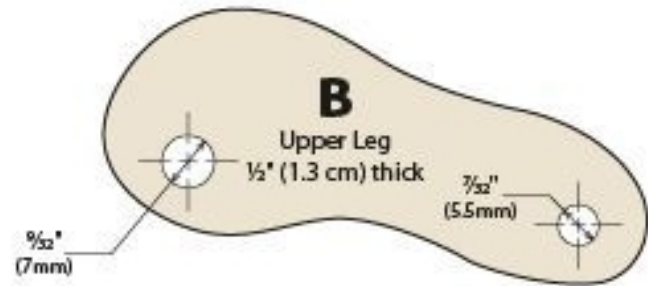
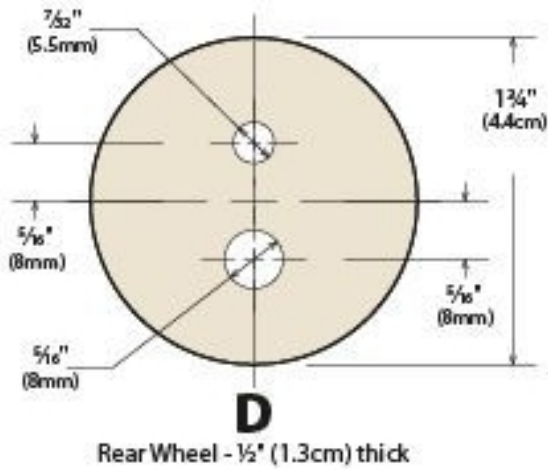
Figure 5.2. Break the edges of the mouth line by pulling the sandpaper through the mouth upward and then downward.



Patterns © David Wakefield

Materials

Part	Description	QTY	Thickness	Width or Diameter	Length
A	Body	1	1½" (3.8cm)	4" (10.2cm)	6" (15.2cm)
B	Upper Legs	2	½" (1.3cm)	1¼" (3.2cm)	3" (7.6cm)
C	Lower Legs	2	½" (1.3cm)	1¼" (3.2cm)	3" (7.6cm)
D	Rear Wheels	2	½" (1.3cm)	1¾" (4.4cm) diameter	—
E	Front Wheels	2	½" (1.3cm)	1¾" (4.4cm) diameter	—
F	Rear Axle	1	—	⅝" (8mm) diameter	2¾" (7cm)
G	Front Axle	1	—	⅝" (8mm) diameter	2¾" (7cm)
H	Pegs	6	—	⅞" (5.5mm) diameter	1⅞" (2.7cm)
I	Pull Cord	1	—	¼" (6mm)	28" (71cm)
J	Pull Cord Ball	1	—	1" (2.5cm) diameter	—



Patterns © David Wakefield

6 Busy Beaver

The Beaver has just one simple mechanism: the cam on the rear axle lifts the tail as the axle rotates. This toy has a couple of additional cool features, though. He works in both directions, and if he is pushed quickly, his tail actually makes a slapping sound as it falls. It is also fairly easy to make. You could carve some detail into the tail if you were so inspired.

The Body

I use a fairly large block of wood for the body to make the dado cut a bit safer. Lay out the pattern along the edge of the board with the top of the dado slot parallel to the edge of the board so the dado slot can be cut on the table saw.

I use an 8" (20.3cm) dado but a 6" (15.2cm) dado will work just as well, as long as you end the cut in the same place as the drawings. Passing a handheld piece of wood over the dado is potentially dangerous, so I use four passes to complete the slot, minimizing the risk of the blades grabbing my work and yanking it out of my hands.

Drill the holes in the side of the body. With the dado set at a little over half the width of the slot and half the height, mark the end of the blade on the table with a pencil so you can see how far to cut (see Figure 6.1). Cut until the pencil mark on the side of the body pattern reaches the pencil mark on the table. Carefully bring the piece back off the blades and set the dado to cut the other side of the slot. Raise the table up to the full depth of the slot and repeat the last two cuts. Remember to remark the table, as the blade will emerge from the table farther forward when the blade is raised.

Now, cut out the silhouette on the band saw. I drill the holes for the teeth before I do the sanding. Rest the forehead on the drill press to drill the tooth holes. I use a Forstner bit for accuracy. I use a makeshift stop to set the distance from the sides of the head and then edge sand the silhouette with 80-grit and 120-grit sandpaper on the edge sander. I use a 1" (2.5cm) dowel cut in half on the platen of my sander to sand inside curves (see Toy Making Techniques, Figure 3.12). You can also use a drum sander. Then, flat sand the body sides with 80-grit and 120-grit on the stationary belt sander.



The Beaver's front wheels are attached using a standard axle assembly. The teeth are glued into holes drilled in the bottom of the head.



The cam wheel lifts and lowers the tail as the tail axle turns.



The dado slot cut in the body allows the space for the tail to move up and down.

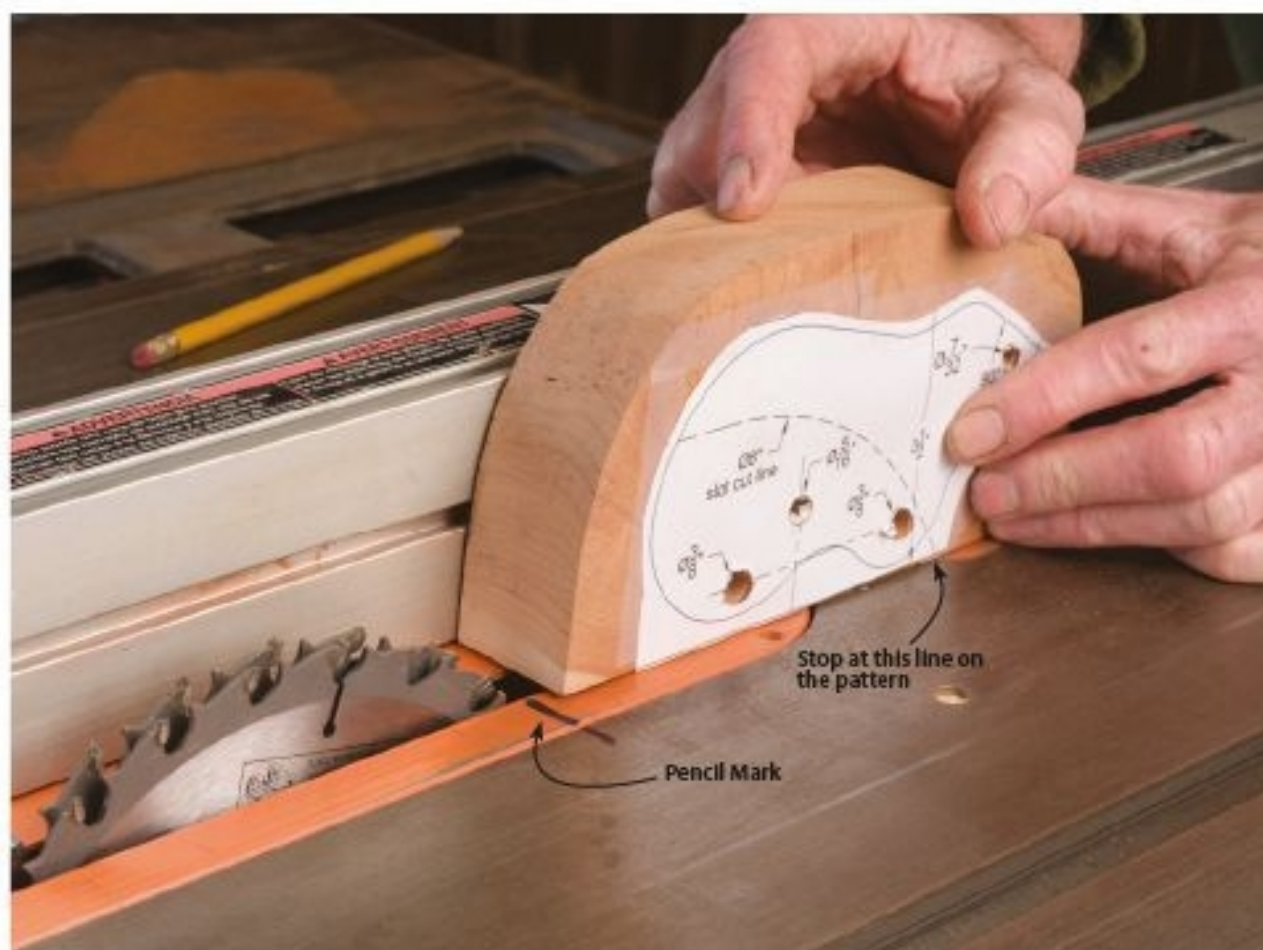


Figure 6.1. Make a mark on the table of the table saw to see where the blade ends so you can make an accurate dado slot. Notice the mark on the pattern as well, which shows where to end the slot.

Use a router to edge the entire silhouette with a $\frac{1}{4}$ " (6mm) quarter-round bit. I use a carbide-tipped bit with a roller bearing to minimize burning. I also move pretty quickly and overlap passes rather than slowing down on curves. Lastly, hand sand all the routed edges with 120-grit sandpaper (use 80-grit first if you burned them).

Cut the $\frac{1}{16}$ " (8mm) dowels to length for the teeth. Hit each end with the edge sander and then slightly round the edges by hand with sandpaper. Glue the teeth in place and carefully cut away the inside curve on the band saw. You can hit that cut edge with a round file to smooth it out a bit.

The Tail

Lay out the side view first. Use the same 1½" (3.8cm) stock that you used for the body, even though the tail is a bit thinner. Drill the pivot hole. Cut out the side view and edge sand with 80-grit and 120-grit sandpaper. Lay out the top view on the top of the tail. You can use the fence on the band saw to cut away the sides of the pivot arm portion of the tail piece or just do it freehand. Be sure to hold the flat part of the tail down firmly on the table top as you make these cuts. Then, cut out the silhouette of the tail itself. Edge sand the tail portion of the piece with 80-grit and 120-grit sandpaper. Round over the edges of the tail by hand with a file and then sandpaper. Lastly, hand sand all the edges with 80-grit and 120-grit sandpaper.

The Wheels and Cam

Use a hole saw of any sort to cut out the wheels and the cam. Drill all the axle holes to ⅝" (8mm). Fill the axle hole of the cam by gluing a short section of dowel into it. Let it dry, and redrill the hole to reflect the offset in the drawings. If you drill it slightly oversized (21/64" [8.5mm]), it will be less likely to split during assembly.

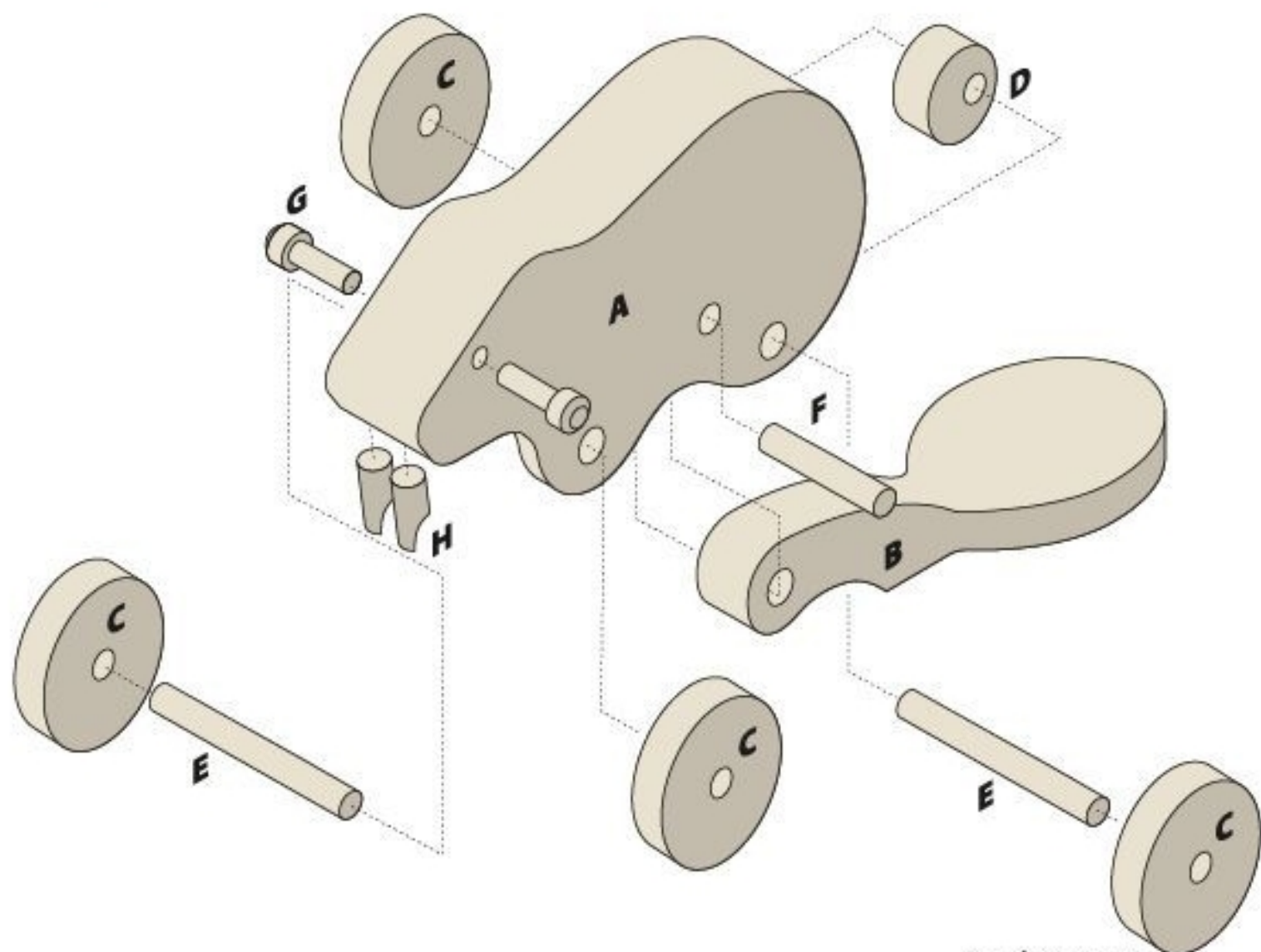
Assembly

Cut the pivot dowel to length and hand sand both ends to slightly round them. With the beaver on its side and the tail in place (off the side of the table), tap the dowel through one side of the body until it slips through the pivot hole in the tail and just enters

the far side of the body. Now put a little glue on the inside of the hole on the far side and drive the dowel home onto wax paper. Wipe off the excess glue, allow it to set up, and lightly flat sand the dowel ends on the stationary belt sander with 120-grit sandpaper. Be careful not to hit the tail with the sanding belt.

Cut the axles to length and hand sand the ends to round them slightly. Put glue inside one wheel hole, and, with the wheel flat on wax paper, tap the axle firmly in place with a hammer. Wipe off the excess glue. With the Beaver on its side and the tail off the edge of the table and the cam in place, slide the dowel through the axle hole in the body side and start it into the hole in the cam. Tap it through the cam and into the hole on the other side of the body. Now, extend that hole over the edge of the table (support it as close to the hole as you can) and continue to tap the dowel through until you have about a ⅛" (2mm) gap between the wheel and the body side (see Toy Making Techniques, Figure 3.13). Put a little glue on the inside of the second wheel and tap it into place with a hammer. Wipe off any excess glue. Repeat the process for the front axle (except the cam business). When the glue has dried, edge sand the ends of the axles. Lastly, with the Beaver on its back, drill a ⅜" (3mm) hole straight down through the cam and the axle. Glue a short piece of ⅜" (3mm) dowel in the hole to keep the cam from spinning freely on the axle. Make sure the surface of the cam is still smooth, or it will interfere with the lifting of the drive dowel.

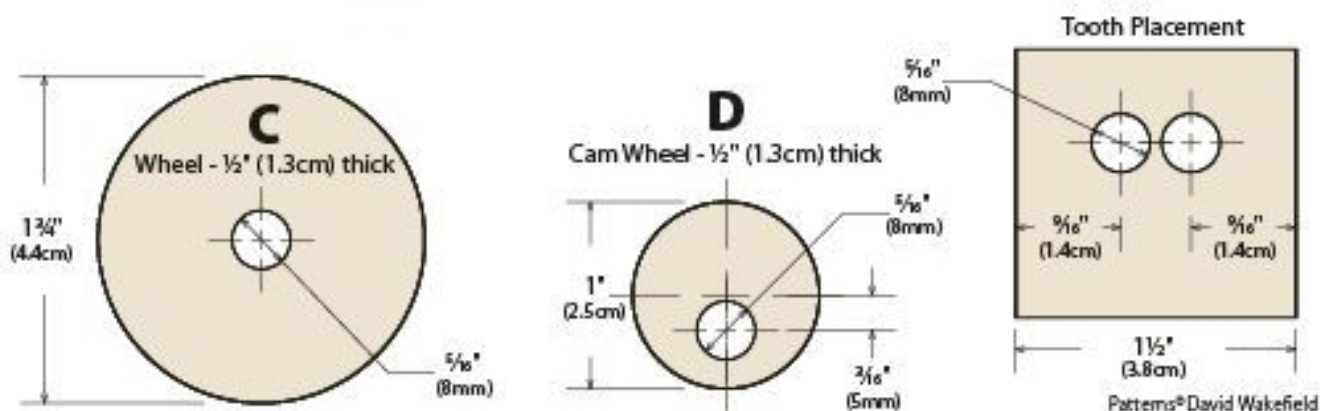
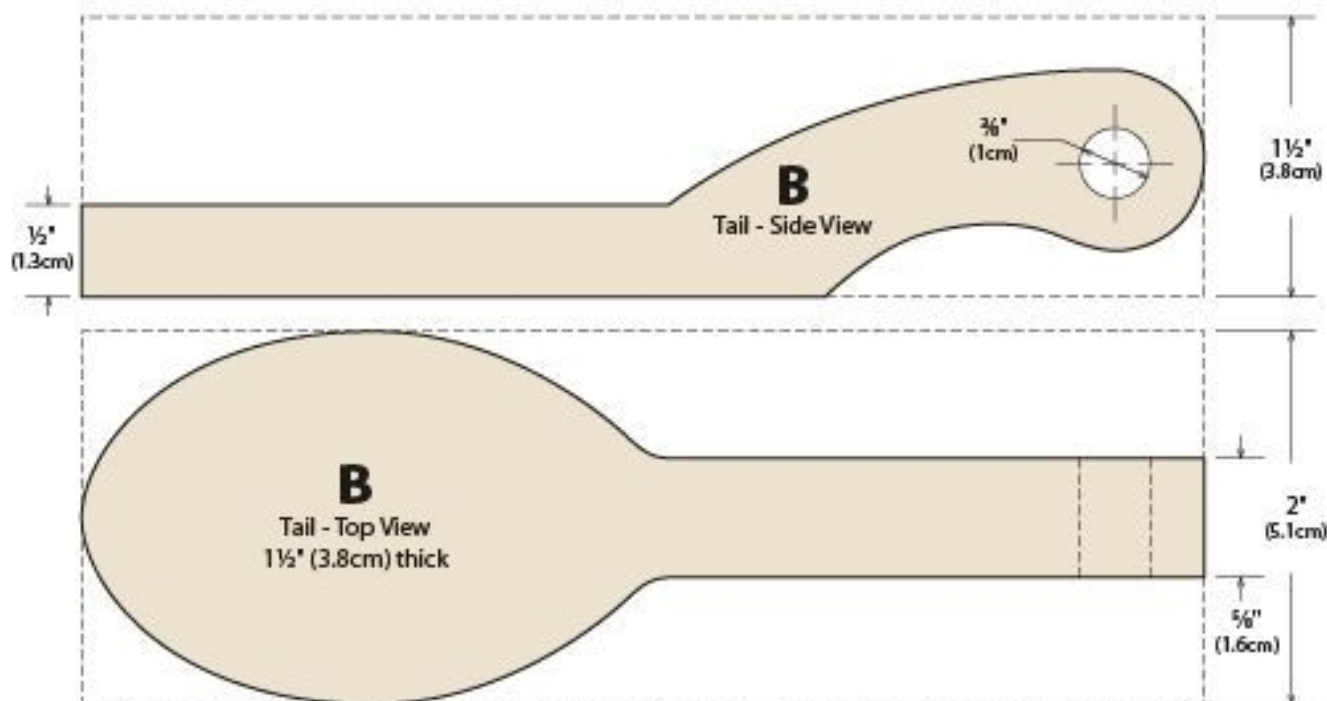
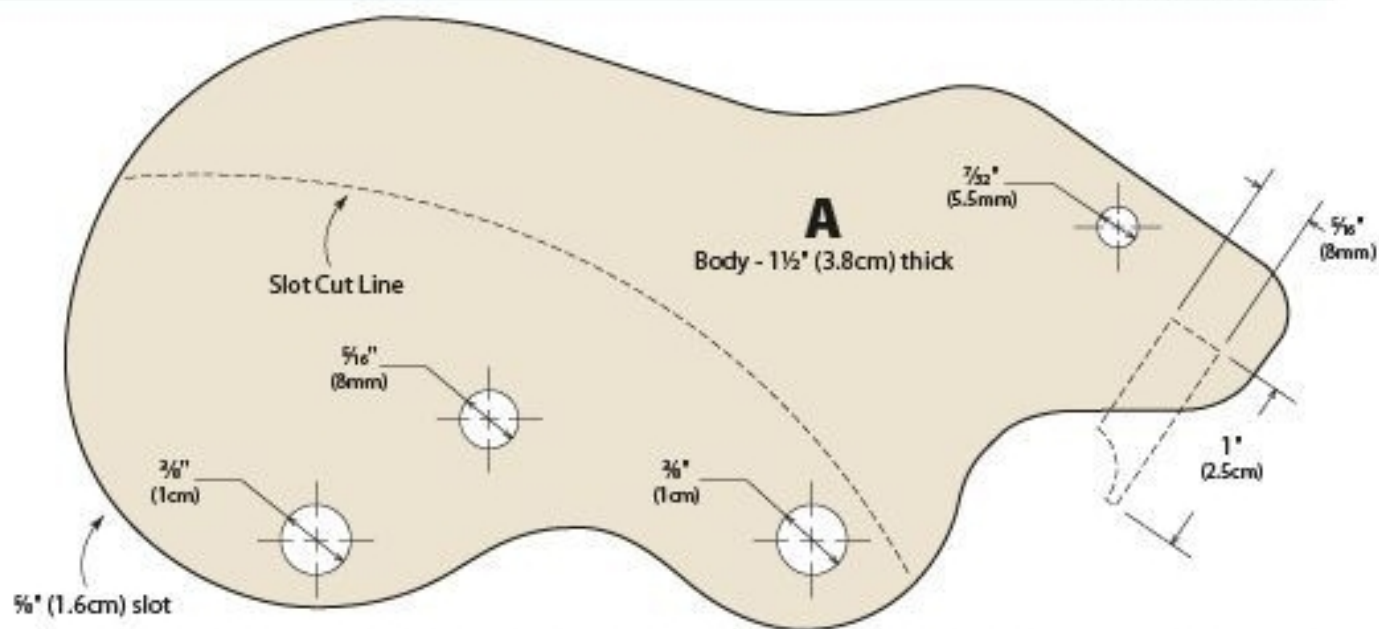
Oil him up, and there you have it: the consummate Beaver, replete with slapping tail.



Patterns © David Wakefield

Materials

Part	Description	QTY	Thickness	Width or Diameter	Length
A	Body	1	1½" (3.8cm)	3¾" (9.5cm)	6½" (16.5cm)
B	Tail	1	1½" (3.8cm)	2" (5.1cm)	6" (15.2cm)
C	Wheels	4	½" (1.3cm)	1¾" (4.4cm)	—
D	Cam Wheel	1	½" (1.3cm)	1" (2.5cm)	—
E	Axles	2	—	⅝" (8mm) diameter	2¾" (7cm)
F	Tail Axle	1	—	⅝" (8mm) diameter	1½" (3.8cm)
G	Eyes	2	—	⅜" (5.5mm) diameter	⅝" (1.6cm)
H	Teeth	2	—	⅝" (8mm) diameter	⅝" (1.6cm)



7 Swaggering Seal

When you pull this toy, its simple shape comes to life. It gets its convincing waddle by means of the diagonally opposed offset wheels and its flippers that spin on the ends of the axle.

The Body

There are no special requirements to consider when you're choosing a piece of wood for the Seal's body. Just about anything will do. Transfer the body pattern to a piece of 1½" (3.8cm) stock. Drill the axle and eyeholes.

Next, cut out the body shape. Edge sand it with 80-grit sandpaper. Flat sand it with 80-grit and then 120-grit sandpaper. Using a block to support the body, position the body at the proper angle on the drill press table and drill the ½" (1.3cm) hole in the back of the Seal's neck. Then, flip it over and support it as you drill the ¼" (6mm) hole that forms the chest. Drill the hole slowly, backing the bit out to clean the hole just before you gently break through. Edge sand the body with 120-grit sandpaper. Router all the edges.

Now, transfer the tail pattern onto the upper surface of the Seal's tail. Cut the slices out on the band saw and round the back corners of the tail. Edge sand the newly sawn areas with 80-grit and then 120-grit sandpaper. Smooth out the areas where the new saw cuts meet the previously flat-sanded areas. Now, clamp the Seal in your vise with the tail sticking up. Using the curved side of the four-in-hand rasp, round over the edges so they resemble the routed edges. Smooth these areas with the curved file with the four-in-hand rasp and hand sand the corners with 80-grit sandpaper. Hand sand all the routed and filed areas with 120-grit sandpaper. Hand sand the sawn areas on the tail with 80-grit and then 120-grit sandpaper, working *with* the grain to remove the vertical sanding marks from the sander or grinder.

The Flippers

The flippers should be made out of a strong wood. Cut out a perfectly square 3" x 3" (7.6 x 7.6cm) piece of ¾" (1.6cm) stock. Lay out two flippers with the grain running lengthwise. The end of the flipper that is to be drilled should be flush against an end grain edge, and the flippers should be perfectly perpendicular to that edge (see Figure 7.1).

Using a center punch or an awl, mark the position of the 2¼" (8.5mm) holes to be drilled. Clamp a square-edged 2x4 to hold the flipper blank perfectly vertical on the drill press table as you drill the holes (see Figure 7.2). I make these holes slightly oversized to prevent splitting the flippers during assembly. If you don't have a 2¼" (8.5mm) bit, you can use a ¾" (8mm) bit and sand the 5/16" (8mm) dowel down some before assembly.



The opposed offset wheels cause the Seal to tip back and forth as it is pulled forward.



Added details like the mouth slot and eye holes help bring this toy to life.



Pegged to the axle, the flippers spin as the wheels turn.

The Wheels

Because the axle location overlaps the true center of the wheel, you'll have to plug the original axle hole and sand it flush before you drill the offset axle hole (see Toy Making Techniques, Figure 3.10).

Assembly

Put glue on the inside of the hole of one flipper. Don't put too much glue in or the dowel won't seat properly. Slip one wheel onto the axle. The outside of the wheel should go first. Put a little glue around the axle next to the flipper. Look at the drawings to position the wheel correctly and slide it up against the flippers. Slip the axle through the body. Holding the whole assembly, carefully put some glue a little farther out on the axle than where the wheel should end up. Keep in mind the $\frac{1}{8}$ " (3mm) clearance between the body and the wheel. Again consulting the drawings, position the second wheel and slip it on the axle.

Remove any glue from the inside of the wheel with a paper match or something similar. Put a little glue on the inside flipper hole. Position it so that both flipper surfaces are perfectly parallel and slip it on.

Before the glue dries, roll the Seal and make any adjustments necessary. When the glue is dry, oil the Seal.

The Pull Cord

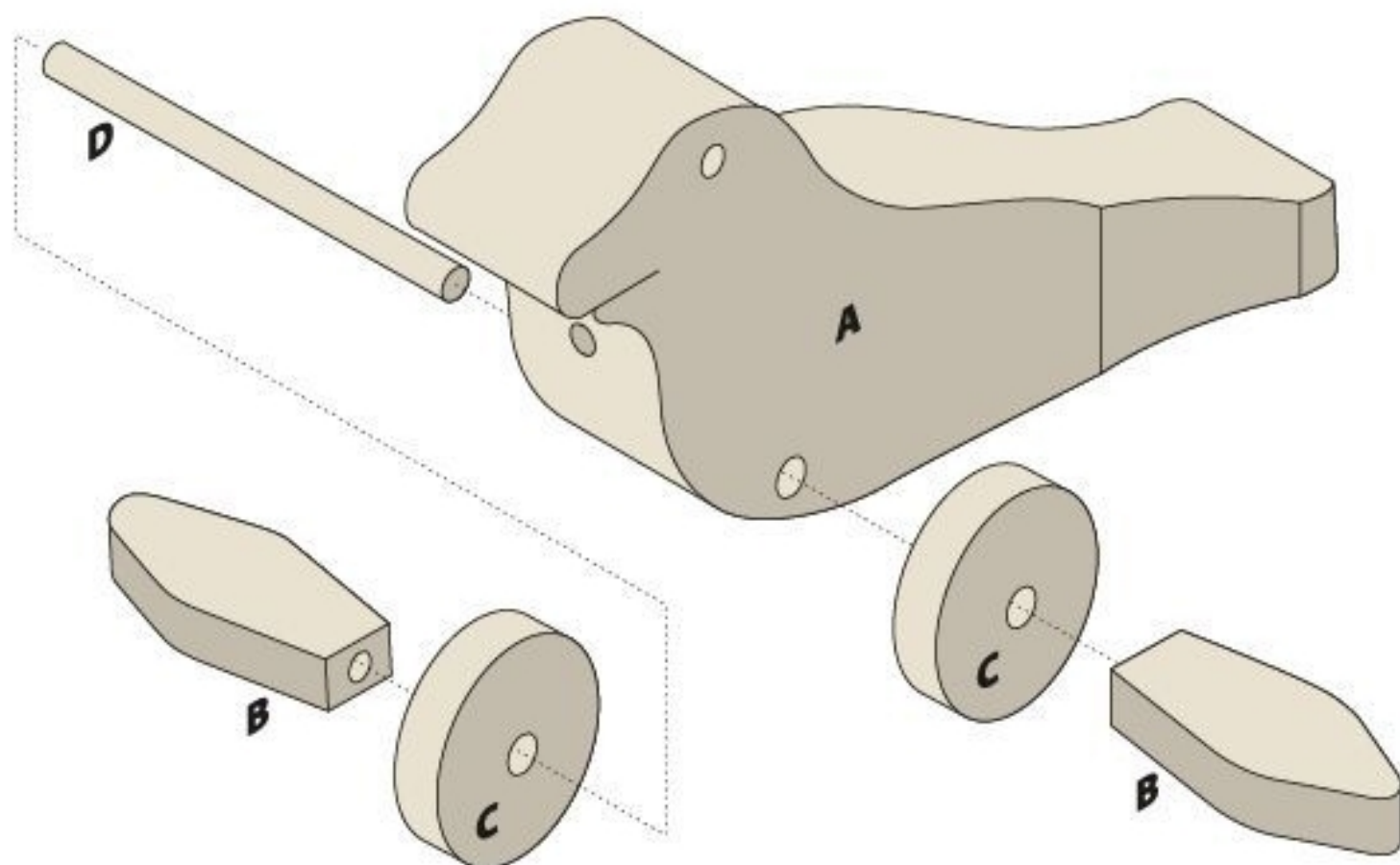
Feed the cord through the hole. Tie an overhand knot in the end sticking out of the $\frac{1}{2}$ " (1.3cm) hole. Pull the cord back through the body until the knot seats at the bottom of the hole. Now tie the bobble on the end of the cord and waddle away!



Figure 7.1. Lay out the flippers perpendicular to the end grain. The edge that is to be drilled should be flush against the end grain edge.



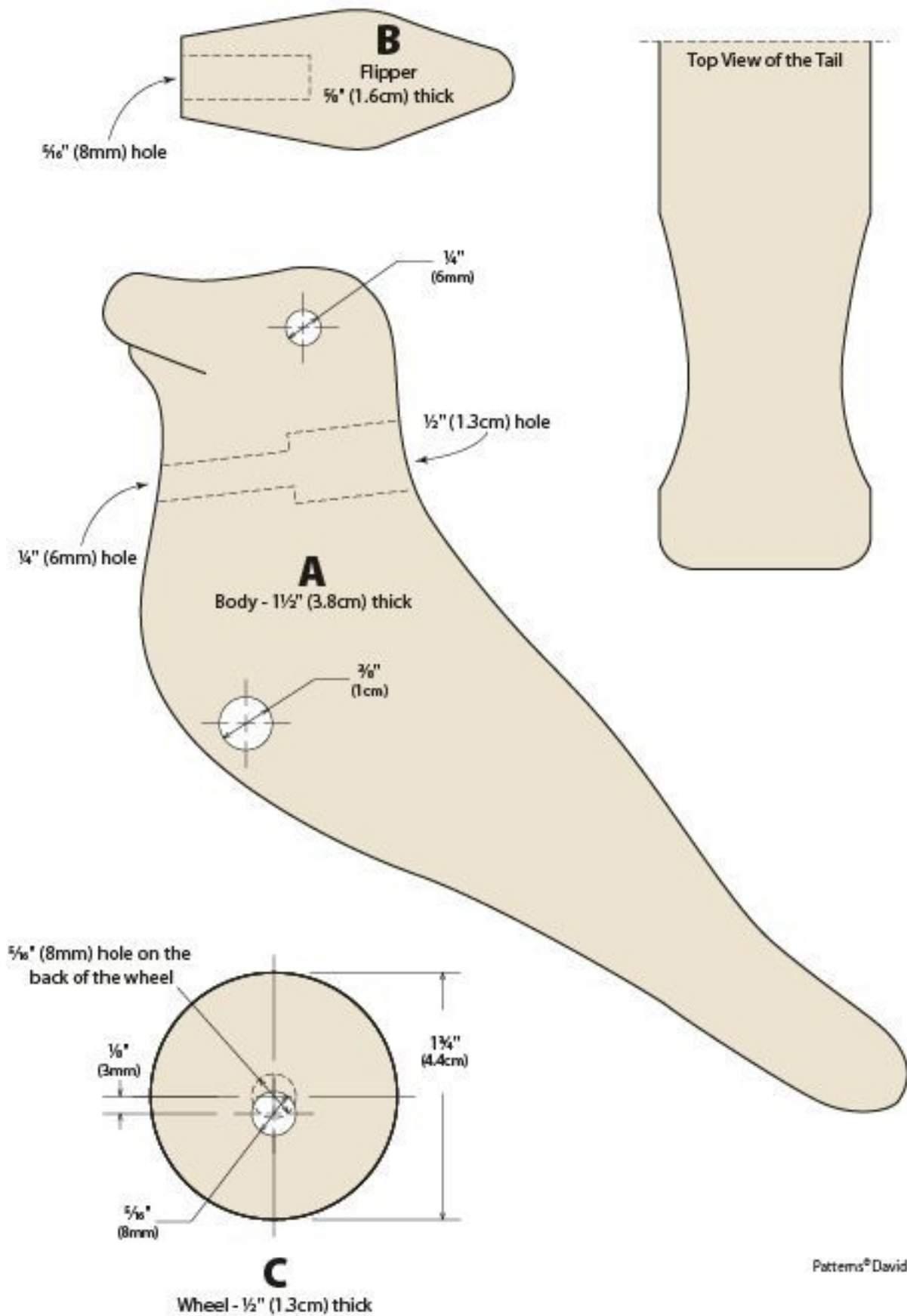
Figure 7.2. Use a square block to hold the flippers perpendicular to the drill press table as you drill the $\frac{7}{16}$ " (6.5mm) holes.



Patterns © David Wakefield

Materials

Part	Description	QTY	Thickness	Width or Diameter	Length
A	Body	1	1½" (3.8cm)	3½" (8.9cm)	8¼" (21mm)
B	Flippers	2	⅝" (1.6cm)	1⅞" (2.9cm)	2½" (1.3cm)
C	Wheels	2	½" (1.3cm)	1¾" (4.4cm)	—
D	Axle	1	—	⅝" (8mm) diameter	2⅞" (7.3cm)
E	Pull Cord	1	—	¼" (6mm)	28" (71cm)
F	Pull Cord Ball	1	—	1" (2.5cm) diameter	—



8 Dexterous Duck

The Duck combines two types of movements to accomplish that convincing waddle. The back wheels have offset axle holes and are assembled in a diagonally opposed fashion so the Duck tips first to one side and then to the other. As the wheels make the Duck tip from side to side, the $\frac{3}{8}$ " (1cm) dowels on the inside of the wheels kick the webbed feet forward one at a time. The combined effect creates an endearing waddle.

The Body

This body does not need exceptional strength, so weaker woods such as poplar can be used. Transfer the body pattern onto a suitable piece of wood. Drill the eye, axle, and peg holes.

Cut out the body on the band saw. To drill the big hole for the front wheel, position the Duck on the drill press at the proper angle to drill the foremost of the two $\frac{3}{4}$ " (1.9cm) holes. Use clamps and blocks to secure it while you drill. If you have a multispur bit, you can drill to the full depth of the hole, reposition the Duck, and drill the second hole.

If you use a spade bit, drill the first hole to the full depth. Reposition the Duck and drill the second hole, stopping before you break through the first one. If you break through into the first hole, the drill bit will bind up and yank the Duck severely, possibly bending the bit. Chisel out the remaining material. File the inside of the hole and round over the lip of the hole with a four-in-hand rasp. Hand sand the lip and sides of the hole with 80-grit sandpaper, and then hand sand the lip with 120-grit sandpaper. Using the same type of setup on the drill press, drill the cord holes. Drill the $\frac{1}{2}$ " (1.3cm) hole first. Reposition the Duck with its chest up and carefully drill the $\frac{1}{4}$ " (6mm) hole until it meets the $\frac{1}{2}$ " (1.3cm) hole.

Flat sand the body with 80-grit and then 120-grit sandpaper. Edge sand the body with 80-grit

sandpaper. The throat and the back of the neck will have to be sanded by hand or with a drum sander. Now, use a router to cut the entire outline of the Duck, except for those edges on each side of the front wheel hole. Round over these edges with the four-in-hand rasp and sandpaper. Edge sand the body with 120-grit sandpaper again, and hand sand the throat and the back of the neck. Hand sand all the routed edges with 80-grit sandpaper to remove any roughness, burns, or splinters. Hand sand all these edges with 120-grit sandpaper.



The wheel plugs are positioned so one is up while the other is down. This moves the legs one at a time so the Duck appears to be walking.



The front wheel is hidden in a space drilled out of the front of the body.



The Duck's legs swing forward and backward on the pegs.

The Legs

The legs should be made of a strong wood so that the webbed areas of the feet won't break off. Transfer the pattern to two suitable pieces of stock. I tap the hole location with an awl, so I don't have to drill through the patterns. Cut out the silhouettes on the band saw. Remove the pattern and drill the $\frac{1}{2}$ " (7mm) peg hole in both legs.

Now lay out the top view patterns and tap the hole locations with an awl. Take off the patterns and drill the $\frac{1}{8}$ " (8mm) holes in both feet. Go ahead and cut the extra wood off the ends of the webbed feet (halfway through the holes), leaving just the webbed ends. Now, clamp each foot one at a time in the vise and make the last two cuts in each foot with a back saw or dovetail saw (see Figures 8.1 and 8.2).

Edge sand the silhouette and the sides of each leg with 80-grit and then 120-grit sandpaper. Smooth out the webs with a rat-tail file and sandpaper wrapped around a dowel. Hand sand all the fuzzy edges with 120-grit sandpaper, and the feet are ready.



Figure 8.1. Cut out the legs with a back saw or a dovetail saw.



Figure 8.2. Make the second cut.

9 Scented Skunk

This is my newest design. It has a unique type of mechanism that I've only used in one other toy (the Hadrosaur in my second book). A fork at the base of the tail goes over the cam on the rear axle and it controls the movement of that bushy skunk tail all the way through its cycle, moving it into that upright threatening position that we never want to see from a skunk. That movement, along with the contrasting stripe, makes for a pretty unmistakable Skunk.

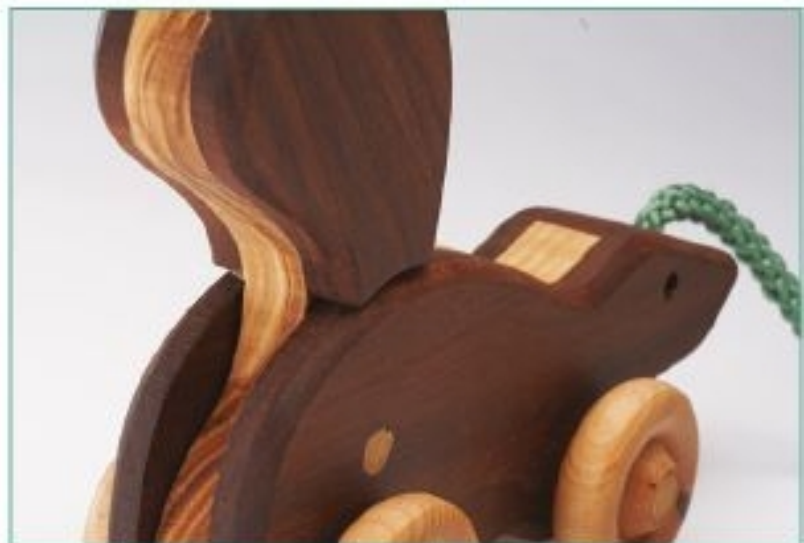
The Body

Lay out the body sides on $\frac{1}{2}$ " (1cm) material. Walnut seems like the obvious choice, but contrast with the stripe is the key. Don't drill the holes until after the body is assembled. Cut out the silhouette, leaving about $\frac{1}{8}$ " (3mm) extra all the way around both pieces. The true silhouette will be sawn after assembly. Mark the intersection of the light stripe piece on the body sides to ensure proper location during glue up.

Cut the two spacer pieces ($\frac{5}{8}$ " [1.6cm] thick) with the grain running nose to tail. Make sure the stripe spacer (maple, holly, poplar, ash, or a similar wood) is exactly $2\frac{1}{2}$ " (6.4cm) wide with straight parallel end cuts for glue up. I use the radial arm saw to do this cleanly, or you could use a band saw and sand the joining surfaces straight on the stationary belt sander. Be sure to hold the pieces perpendicular to the belt so the edges will be at right angles and will glue together properly. Glue and clamp the two spacers side by side (see Figure 9.1).

When the glue is dry, flat sand the assembly lightly to remove any excess glue. Get the entire assembly good and flat because it will be glued between the sides later. Now, apply glue to both sides of this piece and position it carefully on one body side, lining the back side of the strip with the marks on the body side. Place the other side on top, again lining it up carefully, and clamp the assembly with at least four clamps. Don't allow the pieces to shift as you apply pressure.

When the glue has set up, cut out the real body silhouette accurately. Drill all the holes in the body sides. To drill the pull cord holes, rest the body upside down with its forehead on the drill press table and drill the $\frac{1}{2}$ " (1.3cm) hole. Then flip the body over, stand it flat on the axle hole areas, and drill the $\frac{1}{4}$ " (6mm) hole through until it breaks through the $\frac{1}{2}$ " (1.3cm) hole. Now, edge sand the silhouette with 80-grit and 120-grit sandpaper. Flat sand both sides with 80-grit and 120-grit sandpaper and router the entire silhouette. Hand sand the routed edges to remove any burns or burrs.



The contrasting colors of wood enhance the animation of the Skunk's tail.



Figure 9.1. Glue the two spacers together, end grain to end grain, before they are put between the sides. Use plenty of glue, as the end grain tends to absorb more.

The Tail

Lay out the center of the tail with the yoke on the same type of wood as the stripe. The grain should run vertically through the tail for strength. Cut it out on the band saw with a $\frac{1}{8}$ " (3mm) blade or use a scroll saw to make the tight turn inside the yoke. Leave the tail slightly large so you can sand it back to its accurate shape after the sides are glued on. Edge sand the inside of the yolk area with a drum sander or a dowel with sandpaper wrapped around it (see *Toy Making Techniques*, Figure 3.11). Sand it to the point that a 1" (2.5cm) cam fits close but not tight at all. You want to maximize the movement created by a close fit but not be so close that it rubs and creates resistance. Go ahead and edge sand the rest of the yoke area as it will be difficult once the sides are glued on, but don't sand the actual tail until the sides are added.

Lay out the sides of the tail on the same type of wood as the body sides ($\frac{3}{8}$ " [1cm] thick). Cut these pieces slightly larger (like you did the center of the tail), except for the slightly curved line at the bottom edge of each tail side (which will be near the top of the body on the finished Skunk); cut that line right to the pattern. Edge sand that area, router it, and hand sand it on both pieces because you won't be able to sand it after assembly of the tail. Now, apply glue to both sides, working it back away from the routed edge to avoid squeeze out. Press the assembly together carefully to avoid shifting, and then apply clamps, again watching for any shifting as you apply pressure.

When the glue is completely dry, edge sand the silhouette back to the line with 80-grit sandpaper, and then hit it with 120-grit sandpaper. Flat sand both sides with 120-grit.

The Wheels and Cam

The wheels are just 1 3/4" (4.4cm) wheels with nothing done to them. Make a cam using a hole saw with a 1" (2.5cm) i.d. Plug the hole and drill a new one as shown in the pattern. Drill the hole slightly oversized (21/64" [8.5mm]) to reduce the risk of splitting during assembly. If you edge sand the tread surface, be careful to maintain its circular shape. When it is done, test it inside the yoke for fit and make any adjustments necessary.

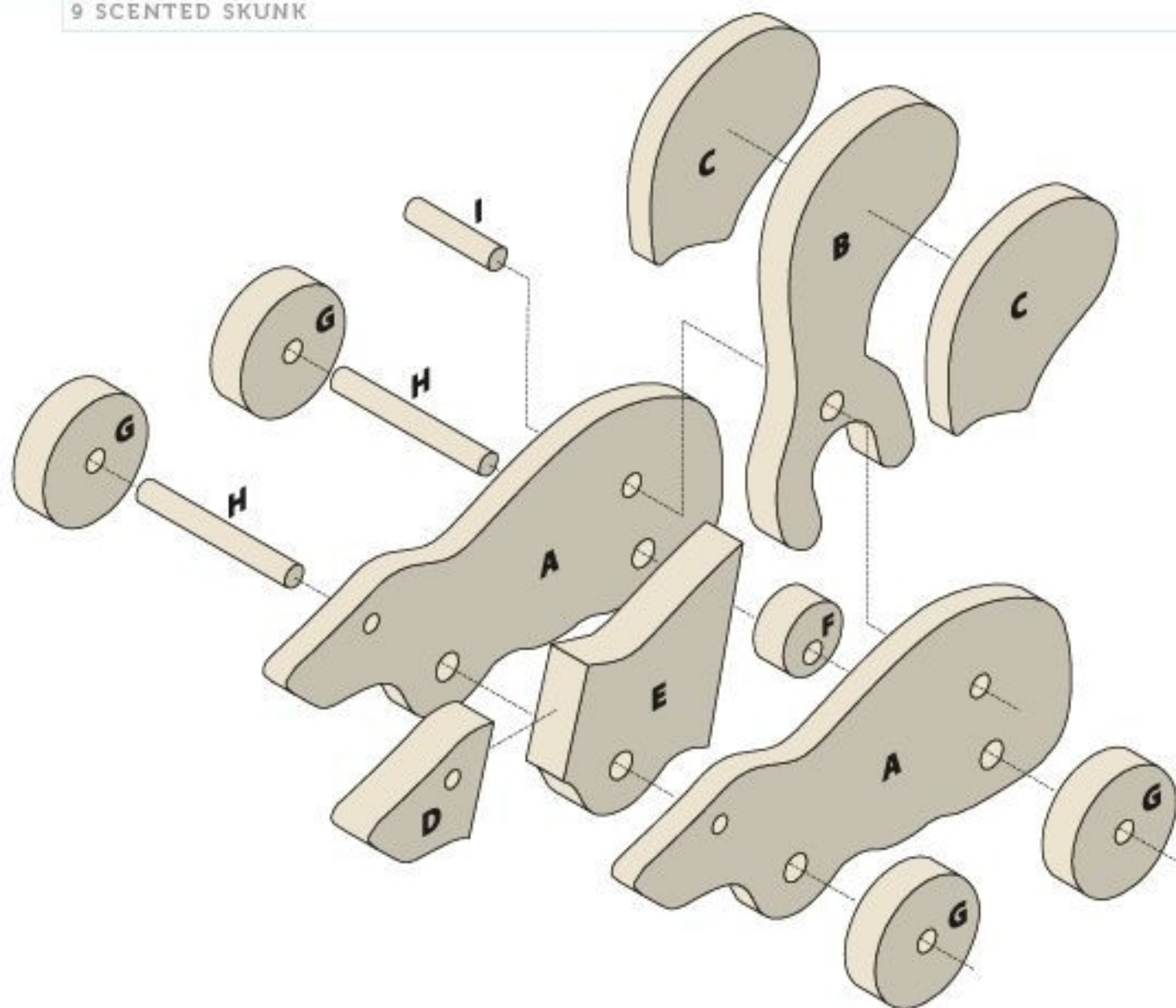
Assembly

Line up the holes to position the tail piece. Cut the 3/16" (8mm) dowel to length but slightly long. Tap it into the hole in the body side, through the tail, and just into the hole on the other side. Then put glue inside the hole on the back side and around the protruding dowel on the near side. Lay the work on

wax paper on the bench and drive the dowel home. Wipe off excess glue and flat sand both sides with 120-grit sandpaper after the glue sets up.

Cut the axles to length, break the ends with sandpaper, and glue each of them into a wheel (driving them home on wax paper and wiping off the excess glue). Position the cam in the yoke with the holes lined up, slide one of the axles through the body side, and tap it through the cam and through the other body side. Place the second wheel on wax paper, put glue in the hole, hold the assembly over the wheel, and drive the axle home, again wiping off any excess glue.

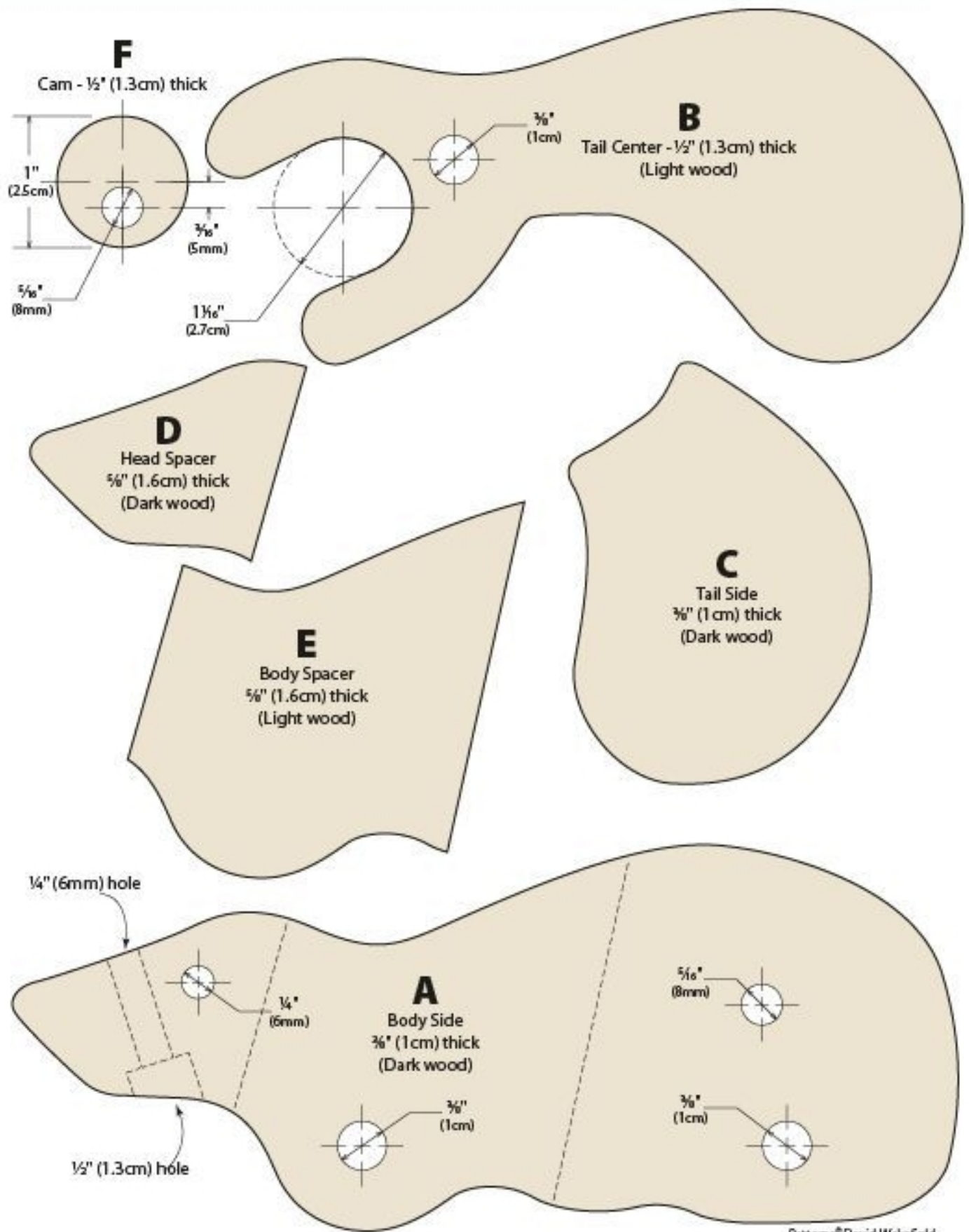
Repeat this process for the front axle (without the cam of course). When the glue is dry, edge sand the axle ends and you're ready to oil this malodorous fellow. When the oil is dry, attach the pull cord and away he goes to threaten the neighborhood.



Patterns © David Wakefield

Materials

Part	Description	QTY	Thickness	Width or Diameter	Length
A	Body Sides	2	$\frac{3}{16}$ " (1cm)	3" (7.6cm)	7 $\frac{1}{4}$ " (18.4cm)
B	Tail Center	1	$\frac{1}{2}$ " (1.3cm)	3" (7.6cm)	5 $\frac{3}{4}$ " (14.6cm)
C	Tail Sides	2	$\frac{3}{16}$ " (1cm)	2 $\frac{1}{4}$ " (5.7cm)	3" (7.6cm)
D	Head Spacer	1	$\frac{5}{16}$ " (1.6cm)	2" (5.1cm)	2" (5.1cm)
E	Body Spacer	1	$\frac{5}{16}$ " (1.6cm)	2 $\frac{1}{2}$ " (6.4cm)	3" (7.6cm)
F	Cam Wheel	1	$\frac{1}{2}$ " (1.3cm)	1" (2.5cm)	—
G	Wheels	4	$\frac{1}{2}$ " (1.3cm)	1 $\frac{3}{4}$ " (4.4cm)	—
H	Axles	2	—	$\frac{5}{16}$ " (8mm) diameter	2 $\frac{1}{2}$ " (6.4cm)
I	Tail Axle	1	—	$\frac{5}{16}$ " (8mm) diameter	1 $\frac{5}{8}$ " (4.1cm)
J	Pull Cord	1	—	$\frac{1}{4}$ " (6mm) diameter	28" (71cm)
K	Pull Cord Ball	1	—	1" (2.5cm) diameter	—



Patterns © David Wakefield

10 Gallivanting Gorilla

Don't get between this fellow and his banana, or you may get hurt. Parallel, offset wheels in the front give him that ape-like gait. His hands are pegged to the wheels to give him the appropriate arm motion. This toy isn't hard to make, but it calls for some careful band saw work to get the facial profile right.

The Body

Transfer the body pattern to a suitable piece of wood. Drill the eye, axle, and peg holes. Cut out the silhouette on the band saw using a $\frac{1}{8}$ " (3mm) blade, or a coping saw, to cut the tight curves on the face. Edge sand the whole body with 80-grit sandpaper, being especially careful on the face outline.

Drill the pull cord holes on the drill press. You can rest the toy on its forehead to drill the $\frac{1}{2}$ " (1.3cm) hole (see Figure 10.1) and then hold it firmly on its heels to drill the $\frac{1}{4}$ " (6mm) hole, or you can use a block of wood (shaped like the back legs) to support it at the proper angle and/or clamp it to a simple jig (see Figure 10.2). Flat sand the body with 80-grit and then 120-grit sandpaper. Use a router to cut the entire outline on both sides. Try not to slow down on the curves of the face area or you'll burn the edges. Edge sand the outline with 120-grit sandpaper again, using a dowel and sandpaper if necessary.

The Legs

Lay out the leg pieces with the grain running lengthwise. Drill the holes, being careful to drill the pivoting holes to $\frac{1}{2}$ " (7mm) and the peg holes to $\frac{1}{32}$ " (5.5mm). When you saw out the legs, you can use a scroll saw or a coping saw to saw out the toes. This little line conveys the curled knuckle that so clearly defines an ape's hand, so cut it carefully. Edge sand all the pieces with 80-grit and 120-grit sandpaper. Flat sand with 80-grit and 120-grit sandpaper. If these small pieces make you nervous on the belt sander, you can rub them back and forth on sandpaper on the workbench. I think that the toes lose their definition if you use a router on the legs, so just break the edges with 120-grit sandpaper.



The pull cord is attached using the holes drilled through the Gorilla's body.



Attaching the legs to off-center holes in the front wheels causes the legs to move up and down as the wheels turn.



The Gorilla's legs rotate up and down on the pegs.



Figure 10.1. Rest the Gorilla on its forehead to drill the $\frac{1}{2}$ " (1.3cm) hole for the knot of the pull cord.

The Wheels

To prepare the front wheels, first plug the axle holes. Then, using the drilling jig (see Materials, Tools, and Techniques, Figures 3.9 and 3.10), drill the $\frac{7}{32}$ " (5.5mm) and the $\frac{1}{16}$ " (8mm) holes all the way through the wheels.

Assembly

Lay out the legs in sets before gluing, choosing the best sides to show and making sure that you will have two opposing sets. Then, on wax paper, spread glue in the peg holes in the upper arm pieces and peg the two sets together.

When they're dry, flat sand any glue off the back of the sets.

Glue the back axle and wheels together. I think this toy looks better if you put the hub inward (if you're using raised hub wheels). The dowels look better flush to the smooth surface on the inside of the wheels. Glue the front axle and wheels together, making sure they are perfectly opposed. Line the pieces up before you tap the wheel on because they won't twist—without the $\frac{1}{8}$ " (8mm) axle breaking—after they're driven home. When they're

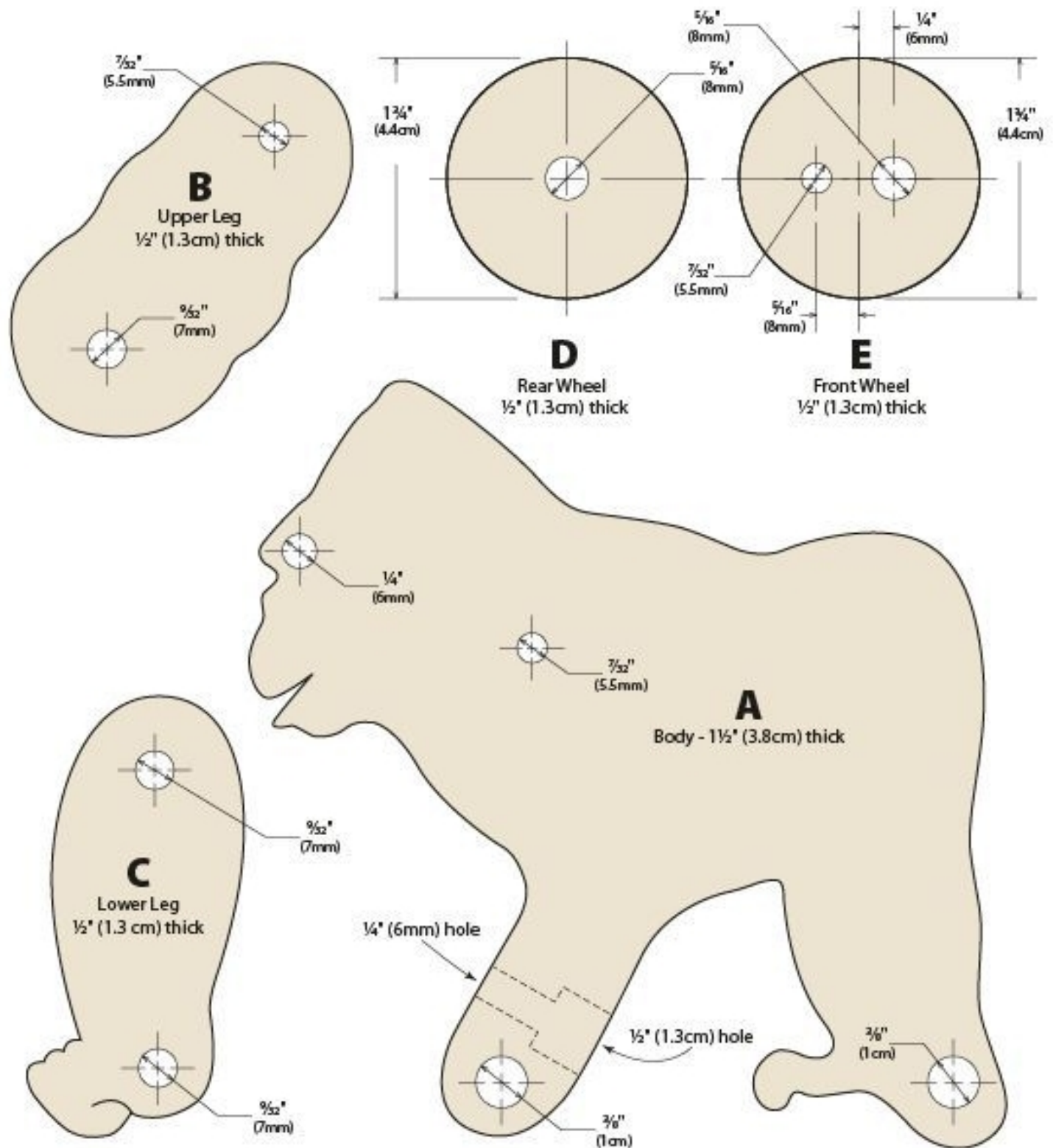
dry, edge sand the wheel surface to remove any glue or fuzz. Next, put glue in the shoulder peg holes in the body. Using the clearance gauge (see *Toy Making Techniques*, Figure 3.13), peg the shoulders to the body.

You may need to cut the pegs a little shorter so they don't stick out the back of the wheel (see *Toy Making Techniques*, Figure 3.5). Now, put glue in the peg hole of one wheel, rest it on the edge of the workbench for support, and peg the foot to the wheel using the clearance gauge. Be careful to wipe any excess glue off the inside of the wheel before it smears onto the body. Repeat this process on the other side.

Allow the glue to dry thoroughly overnight. Then oil your ape and attach the pull cord. One more Mountain Gorilla on the loose.

Figure 10.2. Clamp the Gorilla to a simple jig to drill the $\frac{1}{4}$ " (6mm) hole.





Patterns® David Wakefield

11 Kicking Kangaroo

I have a special affinity for this toy as I was born in Australia. When you were little cuddling up with your Teddy bear, I was snuggling up with a stuffed kangaroo. This Kangaroo's great leaps are accomplished by the offset axle on the large front wheels. The feet, being pegged to the wheels, provide the corresponding leg movements. The upper arms are pegged tightly so that they can be positioned to box with enemies.

Most of the mass of this toy has to be lifted by the front wheels, so it's essential that you use a light wood for the body. The body has no weak areas, so the strength of the wood is not an important factor.

The Body

Transfer the body pattern onto a suitable piece of 1½" (3.8cm) wood. Drill the axle eye and peg holes. Cut out the silhouette on the band saw. Drill the cord holes with the help of blocks or clamps to hold the body in the appropriate position on the drill press. Set it aside to sand and rout with the legs.

The Legs and Arms

Transfer the leg and arm patterns to strong wood. The arms should be laid out with the grain running along the length of the forearms to give strength to the paws. Drill all the holes, paying special attention to which holes hold the peg tightly (½" [5.5mm]) and which holes pivot on the axle pegs (⅜" [7mm]). Cut the parts out on the band saw.

Flat sand all the parts, including the body, with 80-grit and then 120-grit sandpaper. Use a router to cut all the edges of the body. Edge sand all the pieces with 120-grit sandpaper. Hand sand burns and roughness with 80-grit sandpaper, and then smooth all the routed edges with 120-grit sandpaper.

The Front Wheels

Plug the axle holes of the front wheels. When they're dry, drill the new axle holes. Then, drill the peg holes.



The Kangaroo's legs rotate up and down on the pegs.



Attaching the legs to off-center holes in the front wheels causes the legs to move up and down as the wheels turn.



The arms are set in the well-known boxing position.



Figure 11.1. Be sure to assemble the legs in two opposing sets. This may seem obvious, but it's an easy mistake to make, and it's infuriating to have to cut the legs apart and redrill them.

Assembly

Glue the back wheels to the axle. Glue on the front wheels, being careful to get them perfectly opposed. Roll the Kangaroo to make sure it doesn't wobble from side to side; adjust the wheels if necessary. It won't jump easily at this point without the pull cord, so don't get upset if it doesn't seem to want to leap smoothly. Check for wheel alignment right now. When the glue is dry, edge sand the axle ends.

Peg the arms in as firmly as possible without splitting the pegs.

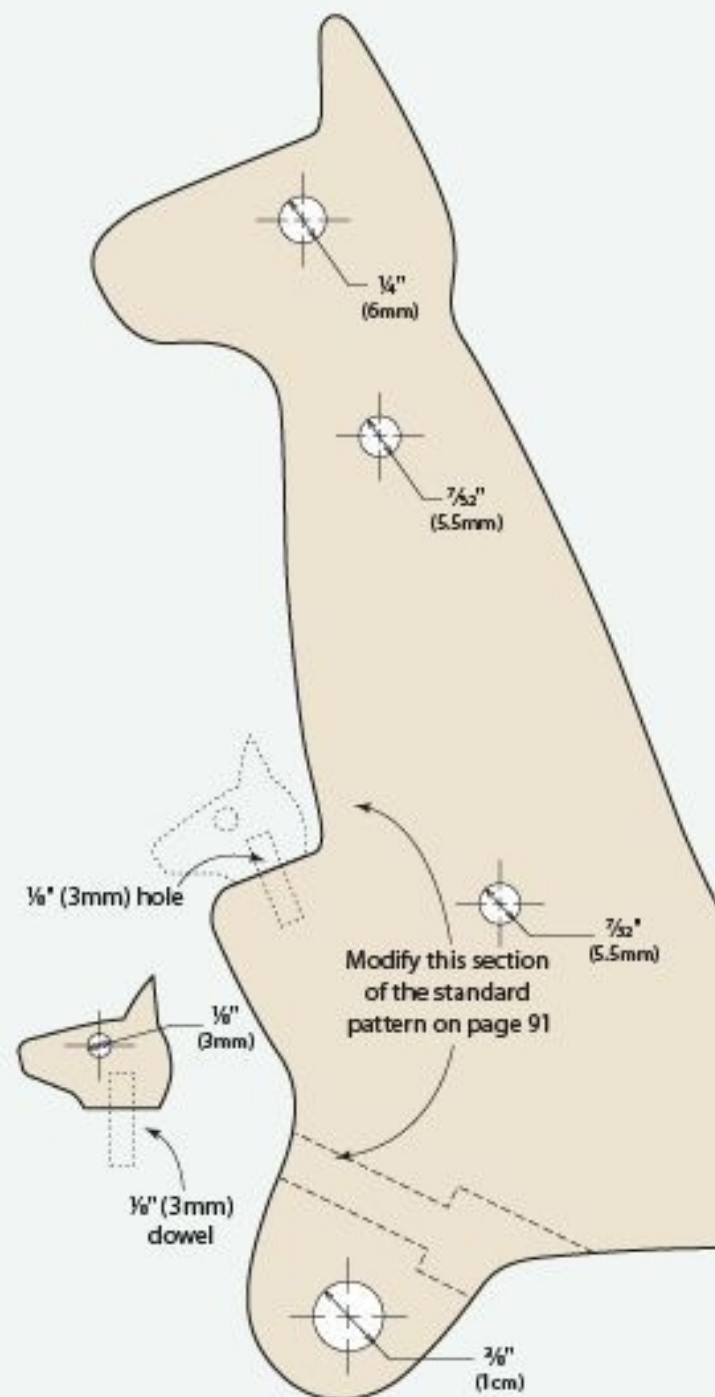
Lay the thigh pieces down, opposing each other, on wax paper. Put glue in the peg holes and attach the corresponding leg pieces, using the clearance gauge (see *Toy Making Techniques*, Figure 3.13). Be careful. It's easy to mix these assemblies up. Visualize both legs on the Kangaroo before you glue them (see Figure 11.1).

Let both assemblies dry. Flat sand the peg ends and glue off the inside surfaces of the thighs.

Now peg the legs to the body, using the clearance gauge. You may need to cut the pegs a little shorter to keep them from protruding out the back of the wheel. Round the tips of the sawn pegs by hand with sandpaper. Using these pegs and clearance gauge, glue the feet to the wheels. Use the edge of the workbench to support each wheel as you drive the pegs home.

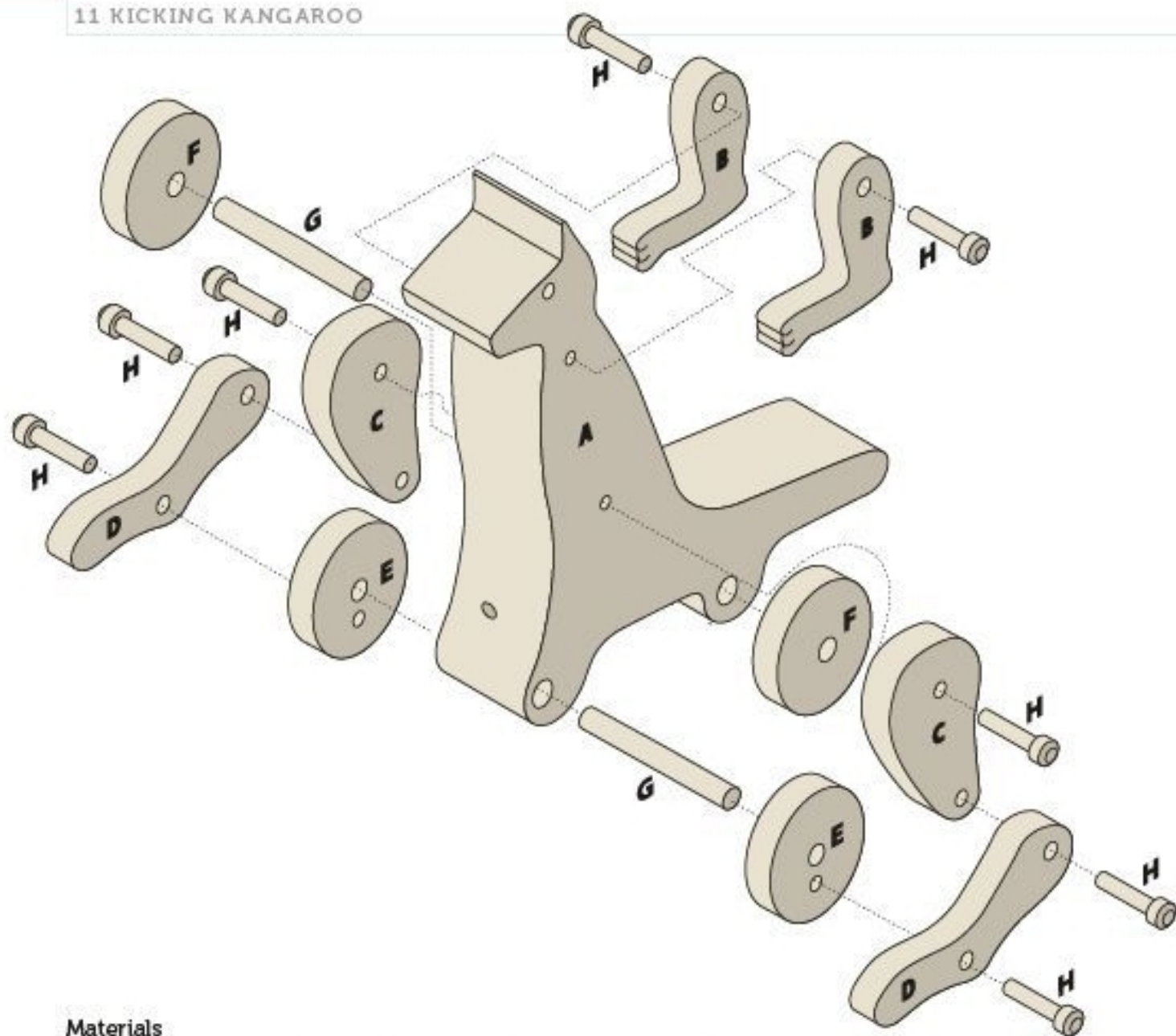
When the glue is dry, you can oil the Kangaroo. When the oil is dry, attach the pull cord and bobble and away you go! Now you can teach your children how they leap over "down under."

Adding a Pouch and Joey



In addition to their huge leaps and bounds, female kangaroos are known for their pouches, which they use to carry their young or "Joey." Adding a Joey to this design is a fairly straightforward process. Modify the pattern for the body (A) to include a pouch and drill the $\frac{1}{8}$ " (3mm) hole. Then drill a $\frac{1}{8}$ " (3mm) hole partway into a $\frac{3}{4}$ " (1.9cm) piece of stock. Cut out the Joey head and use a $\frac{1}{8}$ " (3mm) dowel to attach the pieces.

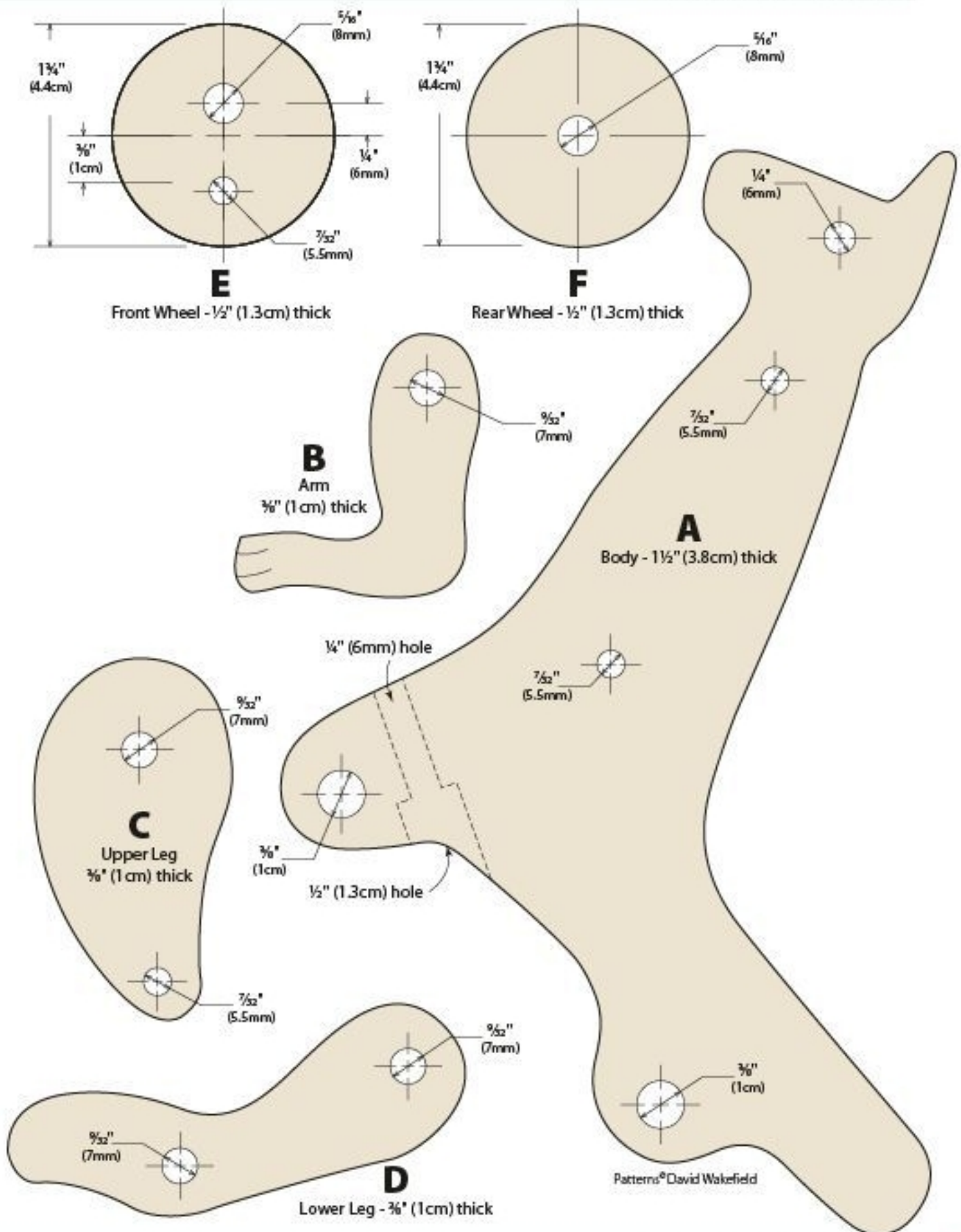
Patterns © David Wakefield



Materials

Part	Description	QTY	Thickness	Width or Diameter	Length
A	Body	1	1½" (3.8cm)	5¼" (13.3cm)	8½" (21.6cm)
B	Arms	2	¾" (1cm)	1¾" (4.4cm)	3" (7.6cm)
C	Upper Legs	2	¾" (1cm)	1⅝" (4.1cm)	3" (7.6cm)
D	Lower Legs	2	¾" (1cm)	1¼" (3.2cm)	3½" (8.9cm)
E	Front Wheels	2	½" (1.3cm)	1¾" (4.4cm)	—
F	Rear Wheels	2	½" (1.3cm)	1¾" (4.4cm)	—
G	Axles	2	—	⅝" (8mm) diameter	2⅝" (6.7cm)
H	Pegs	8	—	⅜" (5.5mm) diameter	1⅞" (2.7cm)
I	Pull Cord	1	—	¼" (6mm) diameter	28" (71cm)
J	Pull Cord Ball	1	—	1" (2.5cm) diameter	—

Patterns © David Wakefield



12 Cross Crocodile

This guy works just like the Hippo and the Lobster. The pegs sticking out on the inside of the front wheels push down on the back of the jaw, lifting the entire jaw and dropping it with an ominous *chomp* as the peg passes the end of the jaw.

The Body

Lay out the body on a suitable piece of stock. Drill the eye and axle holes and cut out the silhouette on the band saw. Edge sand the entire silhouette with 80-grit and then 120-grit sandpaper. Flat sand with 80-grit and then 120-grit sandpaper. Router the silhouette with a quarter-round bit and then lay out the top view of the tail on top of the body. Hold the body firmly down on the band saw table as you cut away the edges of the tail area. Edge sand these sides with 80-grit and then 120-grit sandpaper.

Now, clamp the body in a vise with the tail sticking up and round all the edges with a four-in-hand rasp. I generally rasp first to get the job done and follow up with the file to smooth it out. Then, I do a good hand sanding of these filed areas, as well as the rest of the routed edges, with 80-grit followed by 120-grit sandpaper.

The Head

Lay out the two head sides on $\frac{3}{8}$ " (1cm) stock. Drill the eyeholes as accurately as possible. The distance between the eyeholes and the bottom of the jaw is quite critical for the movement of the head. Leave a little bit of extra wood as you cut the pieces out on the band saw or scroll saw so you can edge sand right back to the line with 80-grit and 120-grit sandpaper. After you have edge sanded the silhouettes of the two pieces, the teeth can be flat. Then, use the flat file again to break the edges of the teeth, putting a nice, clean bevel on each tooth (see Figure 12.1).

The spacer is a bit tricky to cut out safely. I use a much larger block than is necessary to keep my fingers away from the band saw blade. I make the curved snout cut first so I have a big piece to hold onto as I make the easier cut and just let the piece fall away from the blade (see Figure 12.2). You can also use a scroll saw to be safer still.

Edge sand only the bottom edge (the one that can't be sanded after assembly) and round over the relatively sharp back end of the piece. Glue the head together (see Toy Making Techniques, Figures 3.14, 3.15, and 3.16). When the glue has dried thoroughly, edge sand the top of the piece to clean up any discrepancies between the top of the edges of the head sides and the top of the spacer. Break all the edges by hand (except for the teeth) with 120-grit sandpaper.



The front wheel plugs push on the back of the Crocodile's jaw, lifting the head.



The position of the wheel plugs will determine the head motion. This position will produce a steady *chomp-chomp*.



The Crocodile's beveled teeth are an added detail that help bring the toy to life.

The Wheels

The front wheels need $\frac{3}{8}$ " (1cm) holes on the insides (see Toy Making Techniques, Figure 3.9) to house the work dowels. Cut the dowels to length and break the edges. Spread a little glue inside the holes and tap the dowels in place, making sure they are perpendicular to the inside faces of the wheels.

Assembly

Put a little glue inside the eyeholes in the body and peg the head in place, using the clearance gauge (see Toy Making Techniques, Figure 3.13). Cut



Figure 12.1. Use a flat file to put a nice, clean bevel on each of the teeth.

the front axle to length and hand sand both ends to round them off. Spread glue inside both front wheels and tap one wheel home, wiping off any excess glue that squeezes out. Slide the axle through the body and line up the wheels so the one peg is down while the other is up (see Figure 12.3). Drive the second wheel on, diagonally opposed to the first. Repeat the process for the back wheels (without the peg issues).

When the glue has thoroughly set up, edge sand all four axle ends, oil this fellow up, and get ready for trouble.

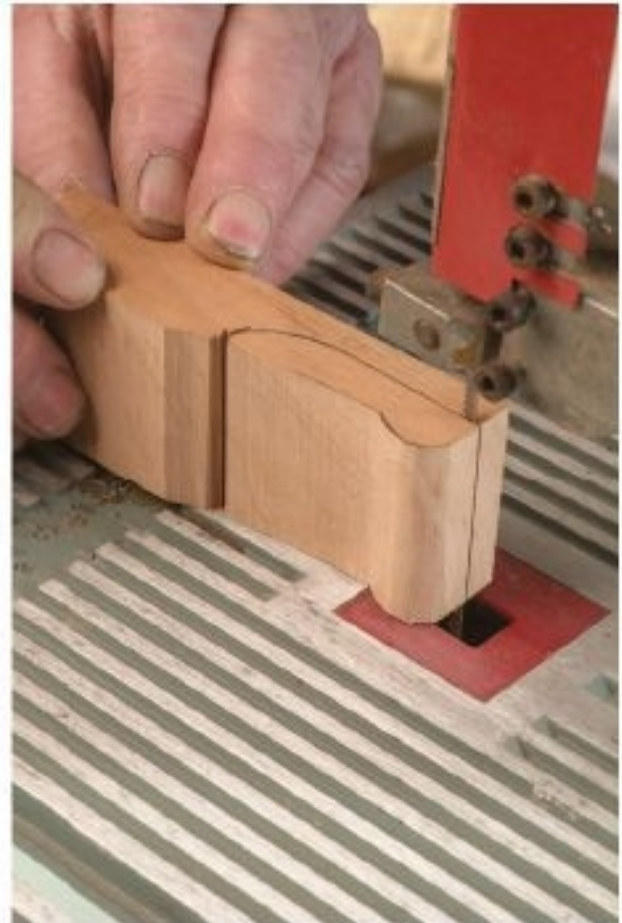


Figure 12.2. Leave a lot of scrap to hold on to as you make the second cut.

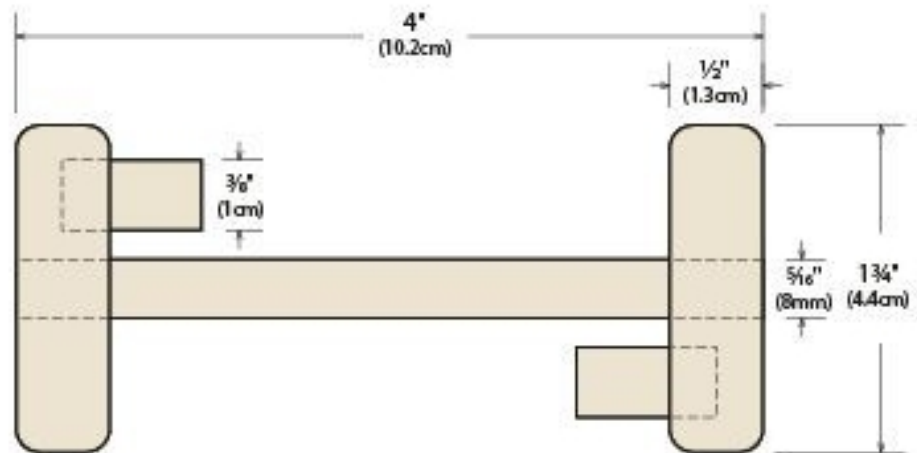
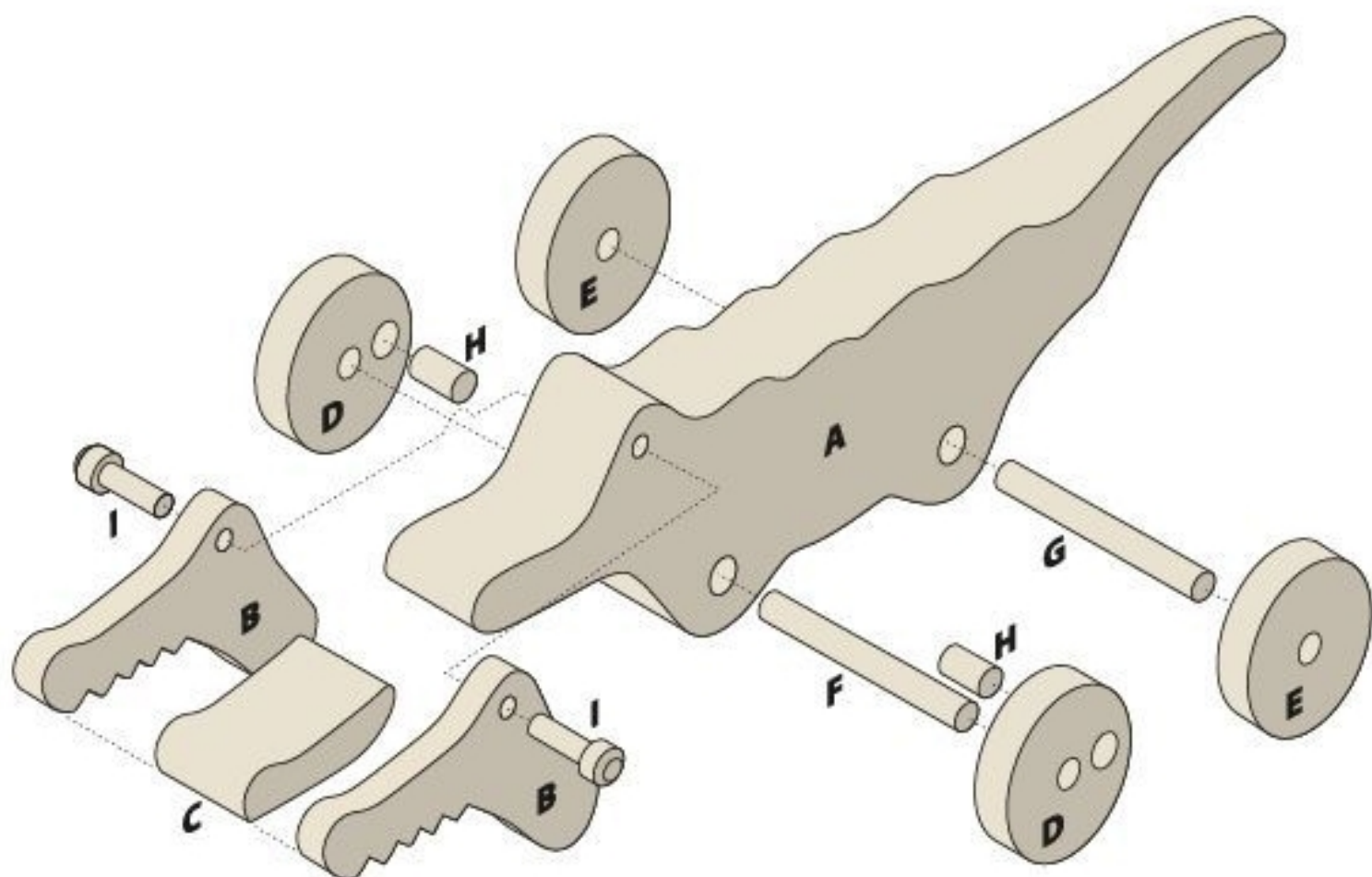


Figure 12.3. During assembly, line up the wheels so the one peg is down while the other is up.

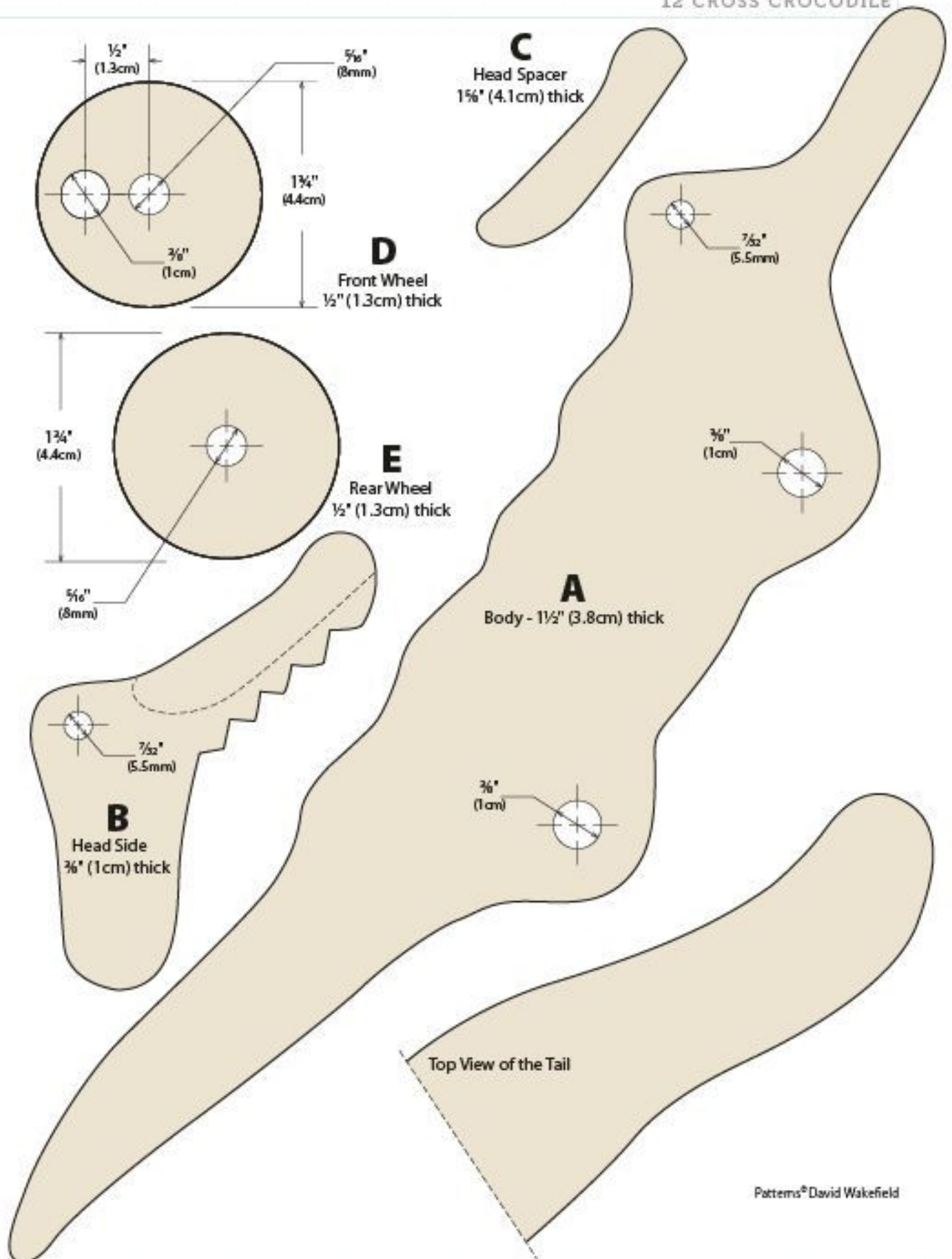
*David Wakefield



Patterns © David Wakefield

Materials

Part	Description	QTY	Thickness	Width or Diameter	Length
A	Body	1	1½" (3.8cm)	3" (7.6cm)	12½" (31.8cm)
B	Head Sides	2	¾" (1cm)	2" (5.1cm)	4¼" (10.8cm)
C	Head Spacer	1	1½" (4.1cm)	5⁄8" (1.6cm)	2½" (5.4cm)
D	Front Wheels	2	½" (1.3cm)	1¾" (4.4cm)	—
E	Rear Wheels	2	½" (1.3cm)	1¾" (4.4cm)	—
F	Front Axle	1	—	5⁄16" (8mm) diameter	3¼" (8.3cm)
G	Rear Axle	1	—	5⁄16" (8mm) diameter	2¾" (7cm)
H	Wheel Plugs	2	—	¾" (1cm) diameter	¾" (1.9cm)
I	Pegs	2	—	7⁄32" (5.5mm) diameter	1½" (2.7cm)



Patterns © David Wakefield

13 Wobbly Walrus

The walrus is certainly an unusual choice for a child's toy. I happen to think that they look rather benign with their ambling gait and their huge jowls and whiskers, even gentlemanly in an odd sort of way. They definitely lend themselves to animation, and they have serious survival issues associated with climate change. So, my criteria for design are clearly met.

This toy presents a few challenges with the dado slot, the drive dowel hole, the shoulders, and the tusks, but they are nothing that a little care can't deal with.

The Body

Lay out the body pattern on a suitable piece of 1½" (3.8cm) stock. I use cherry almost exclusively for my toys, but any relatively light, strong hardwood will do. The top of the dado slot needs to run parallel to the edge of the wood to prepare for the dado slot being cut on the table saw. I leave this piece rather large at this point to make it safe to hold onto the wood as I cut the dado slot. Drill all the holes in the side of the block. Be careful to locate them accurately and to use drill bits of the proper dimension.

I use an 8" (20.3cm) dado but a 6" (15.2cm) dado will work just as well as long as you end the slot in the same place. Passing a hand-held piece of wood over dado blades is potentially dangerous, so I make the dado slot in four passes to minimize the likelihood of the blades grabbing my work and yanking it out of my hands. Set the blades at half the height of the slot, with the fence set to cut to one edge of the slot. (I cut a little more than half the width on each pass.) Before I make the first cut, I mark the end of the blade on the table top with a pencil so I don't go too far when cutting out the slot. Hold the piece very firmly and advance it over the blade until you reach the mark on the body piece that indicates the end of the slot (see Figure 13.1). Carefully back the piece off the blade. Set the

fence to cut the other side of the slot and repeat the steps. Then set the blades to the full height of the dado slot, and repeat the last two steps. Be sure to mark the end of the blade again (on the table saw) as it will change when you raise the blades to their new height.

Once the slot is cut, band saw the silhouette. Be sure to leave the ledge in the front of the head area; it will enable you to drill the drive axle hole. Transfer the vertical line onto the side of the body



The tusks are glued to the bottom of the head spacer and help hide the drive dowel that moves the head.



The cam wheel, hidden inside the dado slot, lifts and lowers the drive dowel, which move the Walrus's head up and down.



The slots cut into the flippers help make this toy as real as possible.

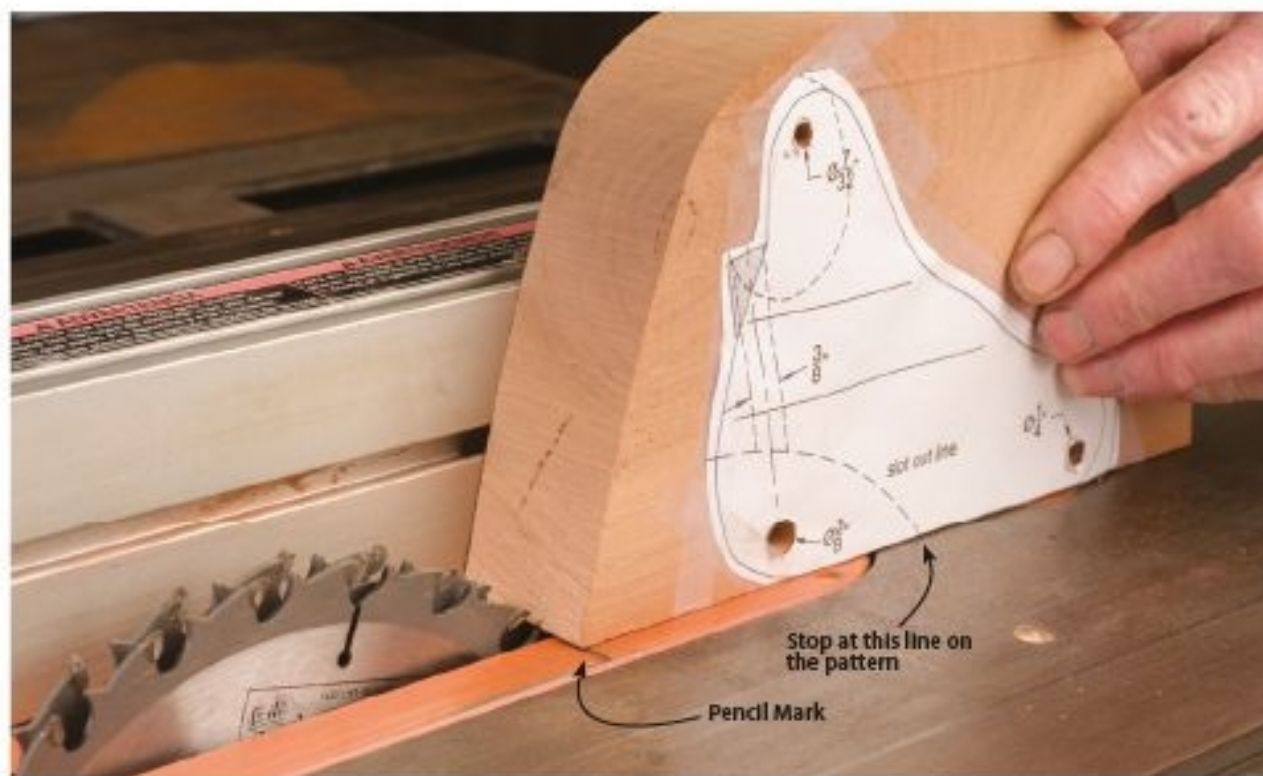


Figure 13.1. I put a pencil mark on the table saw surface to mark the end of the saw blade. That way I can see where to end the cut when the blades are buried in the block.

(for positioning the drive dowel hole) if you haven't done it already. I use two boards glued together at a right angle as a jig (see *Tyrannosaurus*, Figure 21.2). Clamp the body to the jig and carefully drill the drive dowel hole. I use a Forstner bit to prevent wandering.

Now, remove the ledge that enabled you to drill the hole. Edge sand the silhouette with 80-grit and 120-grit sandpaper. Then flat sand the sides of the body with 80-grit and 120-grit sandpaper on the stationary belt sander. Router the entire silhouette with a $\frac{1}{4}$ " (6mm) quarter-round bit.

Lay out the shoulder removal cuts on the back of the head area. You can make these cuts freehand on the band saw, or you can set the fence on the band saw and use stops to make the cuts more accurately. Either way will require a nice, sweeping, curved cut to finish the shoulders. Then, edge sand

these areas with the tail up in the air on the table of the edge sander with 80-grit and 120-grit belts. A light touch with a smooth, sweeping motion will give the best results. Lastly, round over all the head and shoulder area edges by hand sanding with 120-grit sandpaper.

The Flippers

Lay out the flipper pattern for two flippers on $\frac{1}{2}$ " (1.3cm) material, making sure to put the edge that will have the $\frac{1}{4}$ " (6mm) dowel hole drilled in it on the edge of the board. Notice that the board has parallel edges so you can easily drill the holes on the drill press. Once you've drilled those holes, you can put a $\frac{1}{4}$ " (6mm) dowel in each piece—don't glue them. This will make it a lot safer to cut out as well as edge sand the rest of the silhouettes (see Figure

13.2). Cut them out, edge sand them with 80-grit and 120-grit sandpaper, and then flat sand them with 120-grit on both sides. Remove the dowels and hand sand all the edges with 120-grit sandpaper.

The Head

Lay out two pieces of the head pattern on $\frac{1}{2}$ " (1.3cm) stock. Drill the eye-pivot hole in each piece and carefully cut them both out on the scroll saw or the band saw. Leave just a bit of wood beyond the pattern and then carefully edge sand back to the line with 120-grit sandpaper (skipping the area at the top and front where the spacer will meet). It is important that these two pieces be as close to similar as possible for accurate assembly later. Flat sand both pieces with 80-grit and 120-grit sandpaper.

Lay out the spacer on $\frac{3}{8}$ " (2.2cm) stock and carefully cut it out on the scroll saw. Edge sand the underside where the tusks meet. Set the spacer aside for assembly after the tusks have been made.

The Tusks

Lay out the pattern on $\frac{3}{8}$ " (2.2cm) stock. Any strong, light-colored wood will do: maple, ash, holly, even poplar. Cut out the silhouette on the band saw, leaving a substantial extra bit of wood to make all the operations safer. Edge sand and flat sand the tusks with 80-grit and 120-grit sandpaper. Use the fence on the band saw to cut the sides of the slot between the tusks (see Figure 13.3). Remove the fence and carefully nibble away the scrap. Then, hand sand the edges of both tusks. The last step is to cut off the extra wood and edge sand so the pieces fit nicely against the spacer.

Head Assembly

A simple jig can be made to help the accuracy of the head assembly. Drill a $\frac{1}{4}$ " (6mm) hole in a block of wood and glue a 3" (7.6cm)-long $\frac{1}{4}$ " (6mm) dowel in the hole. Hand sand the end of the dowel to round it over slightly (see Toy Making Techniques, Figure 3.14). Then put a little glue on both sides



Figure 13.2. I stick a temporary dowel in the holes in the flippers to make it safer and easier to cut them out and sand them.

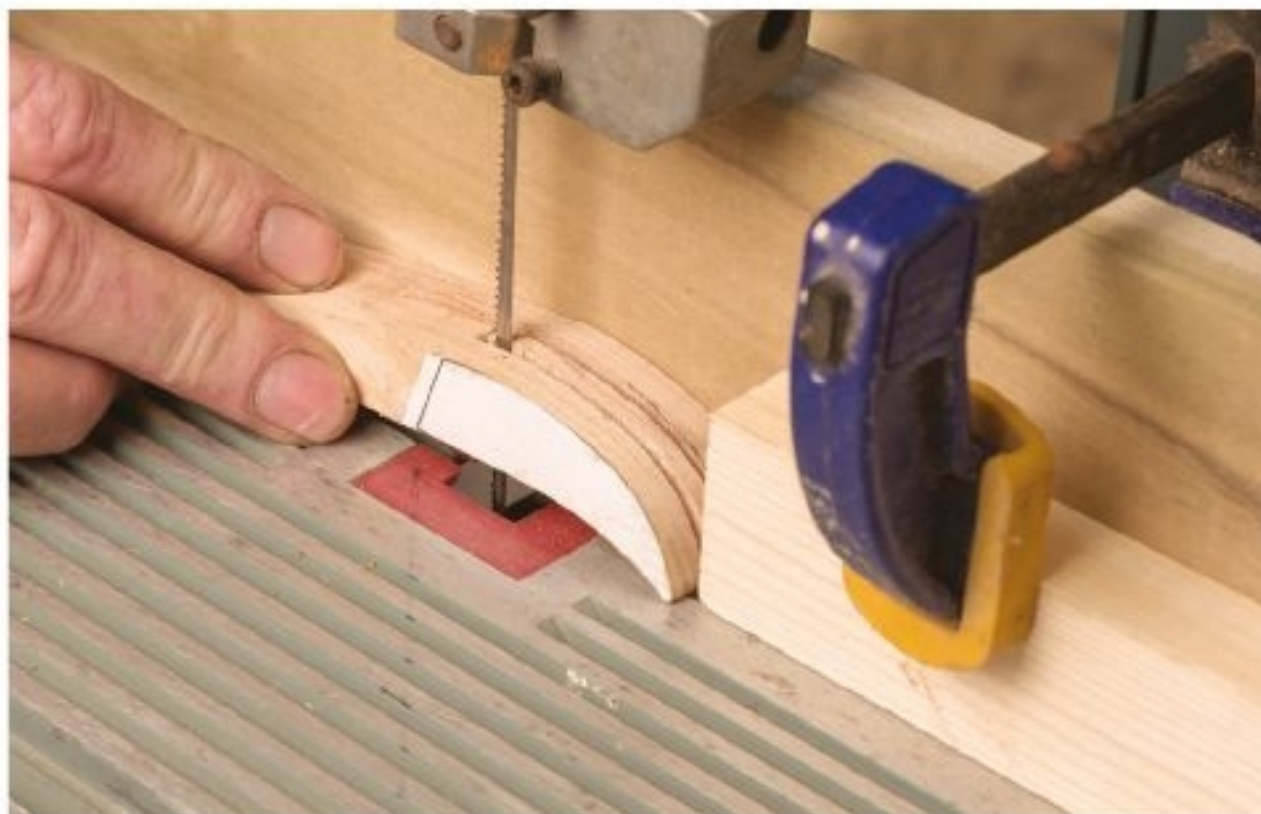


Figure 13.3. Use the fence on the band saw to accurately cut out the scrap between the tusks.

of the spacer and the tusks where they will meet the head sides. I always work the glue slightly back away from the edges to prevent excessive squeeze out. When the assembly has thoroughly dried, edge sand where the spacer meets the head sides. Be careful not to mar the edges of the tusks. Hand sand all the edges of the assembly with 120-grit sandpaper.

The Wheels and Cams

You can either buy 1 3/4" (4.4cm) wheels or make them with a hole saw. In either case, fill the axle holes by gluing dowels in the axle holes and sanding them flush. Then, drill the new offset axle holes as in the drawings. This is what will give the Walrus that characteristic waddling gait. The process is the same for the cam except you will have to make

it with a hole saw with a 1" (2.5cm) I.d. Edge sand the cam, being careful to remain true to its circular shape. Then, do a quick flat sand with 120-grit sandpaper. If you make the hole in the cam slightly oversized ($\frac{21}{64}$ " [8.5mm]), it will be less likely to split during assembly.

Final Assembly

The first step is to attach the flippers. Cut the $\frac{1}{8}$ " (6mm) dowels to length and hand sand the ends to round them slightly. Put a bit of glue in the holes in the flippers and in the body. Spread it around the inside of the holes with a match stick or a toothpick. Tap the dowels into the body sides, leaving the appropriate amount sticking out. Put just a little glue on the edges of the flippers that will touch the body and work it back from the edges to avoid squeeze out. Twist the flippers on until they are almost seated and then tap them into place to avoid smearing glue. Be sure that the flippers are parallel to the bottom of the body and each other.

Now, cut the axle to length and break the edges of the dowel ends with 120-grit sandpaper. Put glue inside one wheel hole and tap the dowel in place with a hammer on wax paper (to keep glue off the workbench). Wipe off any excess glue. Place the cam in the slot, lining up the hole in the body with the hole in the cam. Holding the wheel in your hand, start the axle through the body side and twist it gently into the hole in the cam. Support the body side on the work bench with the grain perpendicular to the workbench surface (to prevent the piece from breaking off). Then, tap the wheel with a hammer and drive the axle through the cam and the other side of the body. Keep going until

there is a gap of about $\frac{1}{16}$ " (2mm) between the near wheel and the body side with the cam in the center of the slot. Spread some glue inside the axle hole of the second wheel. Be sure to perfectly offset the wheels (one up, one down) as you tap the second wheel home. Wipe off any excess glue.

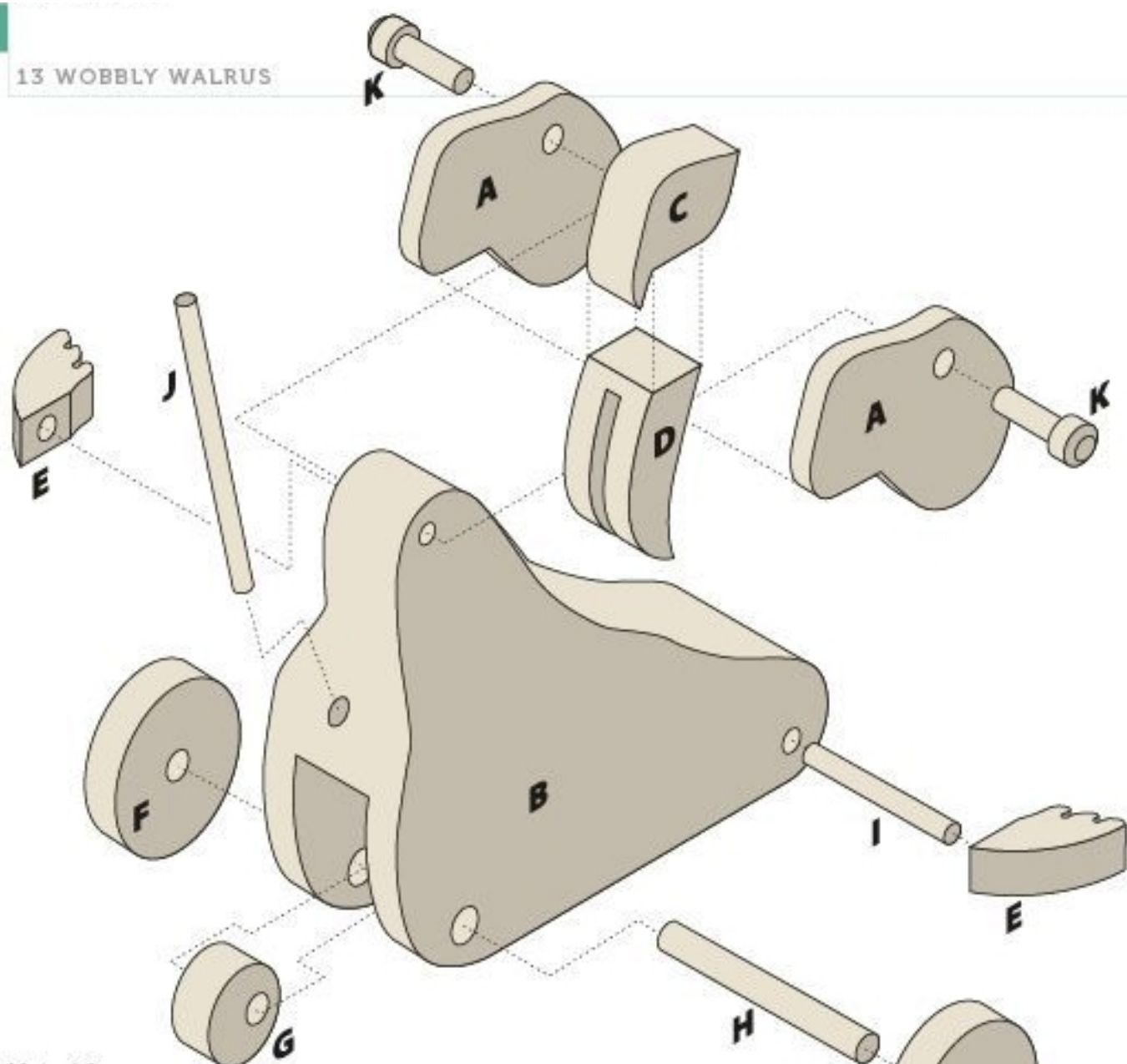
Now, with the Walrus on its back on the drill press, drill a $\frac{1}{8}$ " (3mm) hole straight down through the center of the cam and the axle. Glue a $\frac{1}{8}$ " (3mm) dowel in place to keep the cam from spinning on the axle. When the glue has set up, edge sand the axle ends of the wheels and use a small round file to make sure that the surface of the cam is smooth, so as not to interfere with the movement of the drive dowel.

To attach the head, put a little glue inside both holes in the sides of the head area on the body. With the head in place, slip a peg through the hole in the head and twist it slightly into the hole in the body. A $\frac{1}{8}$ " (3mm) shim between the head and the body will keep you from driving the pegs in too far (see Toy Making Techniques, Figure 3.13).

Cut the drive dowel to length (a bit long) and try it. Shorten it until the head starts to lift as soon as the cam starts to lift the dowel. Then, round off both ends of the dowel to a perfect hemisphere on the edge sander and finally by hand. If you've shortened the dowel too much when you were sanding, just make another one.

Finishing

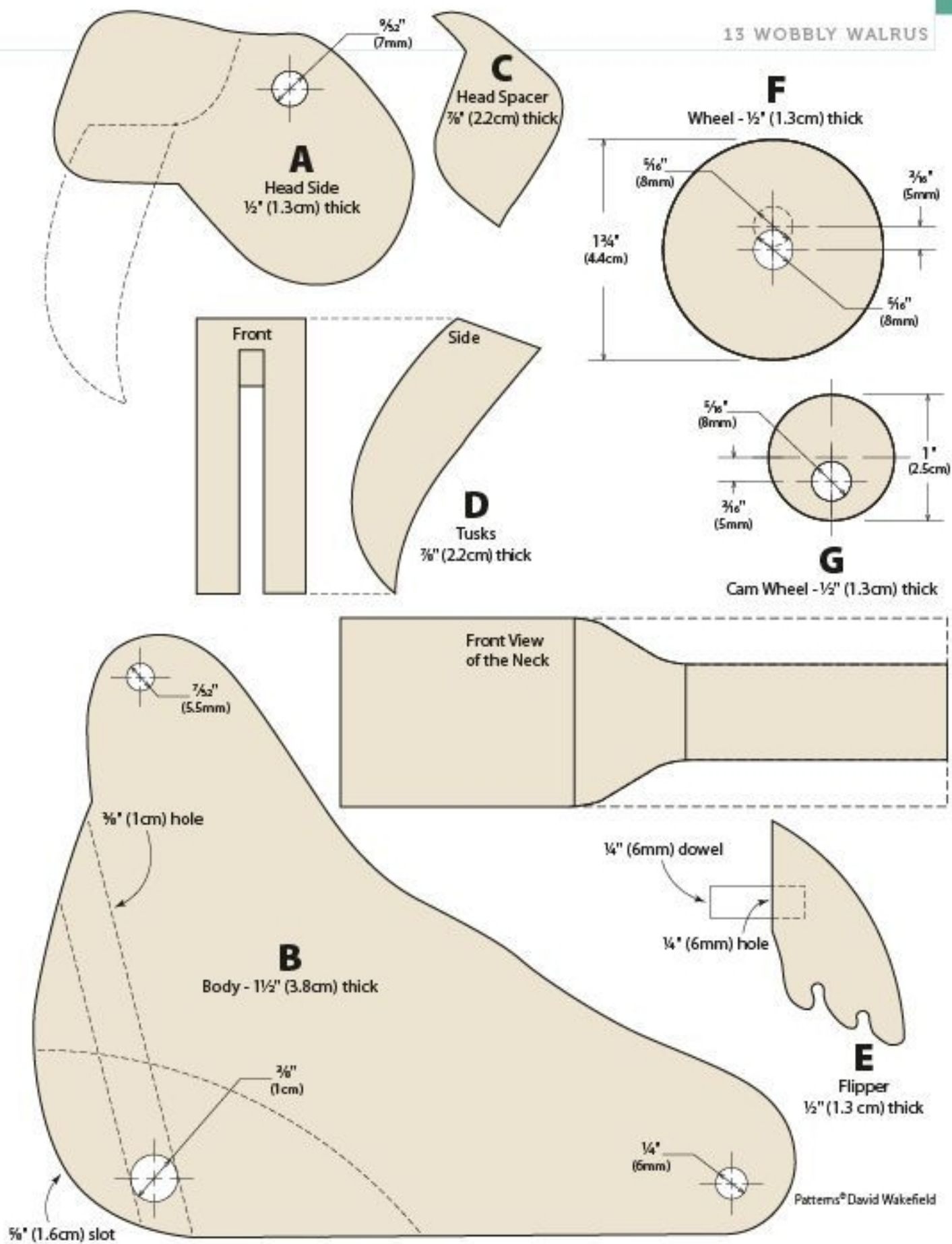
At this point you are ready to oil your Walrus, and there you have it. I hope you are pleased with the results of your efforts. I believe this fellow will be just as happy on a coffee table as in a child's hands!



Materials

Part	Description	QTY	Thickness	Width or Diameter	Length
A	Head Sides	2	1/2" (1.3cm)	2" (5.1cm)	3" (7.6cm)
B	Body	1	1 1/2" (3.8cm)	4" (10.2cm)	7" (17.8cm)
C	Head Spacer	1	3/8" (2.2cm)	1 1/8" (2.9cm)	2" (5.1cm)
D	Tusks	2	3/8" (2.2cm)	1" (2.5cm)	2 1/2" (6.4cm)
E	Flippers	2	1/2" (1.3cm)	1 1/8" (2.9cm)	1 3/4" (4.4cm)
F	Wheels	2	1/2" (1.3cm)	1 3/4" (4.4cm)	—
G	Cam Wheel	1	1/2" (1.3cm)	1" (2.5cm)	—
H	Front Axle	1	—	5/16" (8mm) diameter	2 5/8" (6.7cm)
I	Flipper Axle	1	—	1/4" (6mm) diameter	3/4" (1.9cm)
J	Drive Dowel	1	—	5/16" (8mm) diameter	3 3/8" (8.6cm) (approximately)
K	Pegs	2	—	7/32" (5.5mm) diameter	3/4" (1.9cm)

Patterns © David Wakefield



14 Shredding Shark

I recently revisited this shark design and made some fairly significant improvements. This fellow has my favorite classic, chomping, bad guy action, as well as a sculpted, aquiline physique. He is the consummate wicked predator.

The Body

Lay out the body pattern on 1½" (3.8cm) stock. I prefer cherry for toys because it's fairly strong and light, it sands to a fine finish, it doesn't splinter very easily, and it looks good when oiled, but really, any hardwood will work just fine. In fact, you could make the body out of softwood, but I don't think it would be strong enough for the head.

Drill the eye and axle holes. Cut out the silhouette on the band saw. Edge sand the body with 80-grit and 120-grit sandpaper. If you don't have a curved platen on your 1" (2.5cm) sander, you'll want to use a drum sander for the inside curves around the dorsal fin (see Toy Making Techniques, Figure 3.11).

Flat sand both sides with 80-grit and 120-grit sandpaper and then router the silhouette with a ¼" (6mm) quarter-round bit. I use a carbide-tipped bit with a roller bearing to minimize burning.

Now, lay out the top view on the tail. Hold the work down firmly on the band saw table and cut away the sides of the sculpted tail. Then, edge sand these sides with 80-grit and 120-grit sandpaper. Use a hand saw to cut away the sides of the dorsal fin. I make this cut by eye. Alternately, you could roughly sketch it on before you saw away the sides (see Figure 14.1).

Next, clamp the body in a vise with the tail sticking up at about a 45-degree angle. Start by rasping and then filing the edges of the newly sculpted tail and dorsal fin. Then, hand sand the sides of the tail and dorsal fin with the grain to remove all the crossgrain scratches, using first 80-grit and then 120-grit sandpaper. File the edges of all the teeth from both directions with a small flat file, making a clean bevel on each tooth (see Figure 14.2). Hand sand all the routed edges of the entire silhouette.



The pectoral fin is glued into a slot in the bottom of the body.



The front wheel plugs push on the back of the Shark's jaw, lifting the head.



The careful shaping of the Shark's tail makes it as realistic as possible.



Figure 14.1. A pencil line will help you cut away the sides of the dorsal fins.

The Pectoral Fin

Lay out the fin pattern on $\frac{1}{2}$ " (1.3cm) stock. Cut it out on the band saw. Edge sand and flat sand it with 80-grit and 120-grit sandpaper. Break the edges by hand with 80-grit and 120-grit sandpaper.

The Head

Lay out two head side pieces on $\frac{3}{8}$ " (1cm) stock. Drill the eyeholes. Cut out the silhouettes as close to identical as possible. Edge sand both silhouettes with 120-grit sandpaper, except where the spacer meets the edges. That will be sanded after assembly. Flat sand both sides of both pieces with 80-grit and 120-grit sandpaper. Use a small flat file to put a clean bevel on the outside edges of each tooth (see Figure 14.2).

Lay out the spacer on $1\frac{1}{2}$ " (4.1cm) stock. Leave extra wood to make it safer to cut out the piece on

the band saw and edge sand it. You can make the last cut to the top of the nose (that will be sanded after assembly) after you've sanded the other edges with 80-grit and 120-grit sandpaper.

I make a simple jig for accurate assembly of the head (see Toy Making Techniques, Figures 3.14, 3.15, and 3.16). Put glue on the sides of the spacer, work it away from the edges to avoid squeeze out, and clamp the head sides to the spacer using the jig to help line things up perfectly.

When the assembly has thoroughly set up, edge sand the top and front of the jaw with 80-grit and 120-grit sandpaper. Then, lay out the top view and cut away the sides of the nose area on the band saw. Edge sand and then hand sand the nose with 80-grit and 120-grit sandpaper (with the grain) to remove the crossgrain scratches. Hand sand all the edges with 120-grit sandpaper.

The Wheels

Either buy the 1 3/4" (4.4cm) wheels or make them with a hole saw. In either case, you'll need to locate and drill the 5/16" (8mm) holes inside each wheel for the dowels that will open the jaw as the wheels turn. Cut the dowels to length and hand sand both ends to round them over slightly. Put a little glue inside the holes with a toothpick or a match stick and drive the dowels in with a hammer. Make sure they end up perpendicular to the wheel's surface.

Assembly

The first step is to glue on the head. Put a little glue inside each of the eyeholes in the body. Position the head, slide one peg through the eyehole in the head, and start it into the hole in the body with a little twist. Then tap it in until there is about a 1/16" (2mm) clearance between the head and the body. A clearance gauge (see *Toy Making Techniques*, Figure 3.13) will help with assembly.

The back wheels are pretty simple. Cut the dowel to length. Hand sand the ends to round them off. Put a bit of glue inside the axle holes. Place one wheel on the workbench on some wax paper (to keep glue off your bench) and drive the dowel home. Wipe off any excess glue. Slide the axle through the body, lay the other wheel on the wax paper, start the dowel into the hole, and drive it home. Again, wipe off any excess glue.

The front wheels are a bit tricky. Drive a dowel into one of the wheels in the same fashion. Then you need to make sure that the dowels on the inside of the wheels are diagonally opposed (one up and one down) as you hammer on the second wheel. Be sure not to make them so tight that the head is pinched. If this happens, saw the assembly apart, saw the dowels flush, redrill the axle holes, cut a new (longer) dowel, and try again. Wipe off any excess glue and edge sand the axle ends when the glue has set up.

The pectoral fin is simply clamped in place with glue on the joined surfaces. Once all the glue has dried, you're ready to oil up the Shark and there you go—*chomp...chomp...chomp*. I honestly think that adults should let themselves have one of these fellows on their coffee table. We're allowed to have fun too!!

Figure 14.2. Use a small flat file to put a nice, clean bevel on the edges of each tooth.



15 Loco Lobster

Every child needs at least one “bad guy” toy, and here he is! When the dowel pegs on the insides of the wheels pass by the edge of the claw, they push that end of the lever down, lifting the rest of the claw up in a threatening manner. As the peg continues around, one claw snaps shut in a nasty fashion as the other claw opens. I don’t mean to give this toy “bad press”—it’s a great creature and an endless source of fascination.

Wood Considerations

The body of the Lobster must be made of a strong wood. This will give the toy forward momentum, which helps the claws open. The arms need to be strong to withstand the constant stress of the falling claws. The claws need to be tough but not too heavy, so they’ll lift properly. Looking at all the requirements, it seems that cherry, with its natural red color, is the best choice.

The Body

Lay out the body pattern with the bottom of the body running along a jointed edge. This will enable you to use the rip fence on the band saw to cut an accurate tail slot and create a stronger glue joint.

Drill the $\frac{3}{4}$ " (1.9cm) hole and cut out the body on the band saw. Edge sand with 80-grit sandpaper. Use clamps and/or blocks to hold the body at the proper angles on the drill press and drill the peg holes for the two eyes.

Flat sand the sides with 80-grit and then 120-grit sandpaper. Router all the edges except those around the tail joint. Edge sand with 120-grit sandpaper and hand sand all the routed edges with 80-grit and then 120-grit sandpaper.

The Arms

Transfer the arm pattern to two pieces of stock with the grain running lengthwise. Drill the $\frac{3}{4}$ " (1.9cm) holes with a spade bit. Use the spade bit point hole as a centering device and drill the rest of the way with a $\frac{3}{8}$ " (1cm) twist drill. Don’t forget a piece of scrap under the arm to avoid tear out. Drill the peg holes. Edge sand and flat sand the arms with 80-grit and then 120-grit sandpaper. Hand sand all the fuzzy corners and edges with 120-grit sandpaper.



The axle housing helps support the weight of the Lobster’s large front claws.



The front wheel plugs push on the back of the upper claws, causing them to open and close.



A space cut out from the bottom of the body allows the tail fin to be glued on.

The Claws

Lay out the pattern for the claw spacers on a piece of wood $\frac{3}{4}$ " (1.9cm) thick, and cut them out on the band saw. Transfer the claw side pattern to four pieces of $\frac{1}{4}$ " (6mm) hardwood. Cut out enough of the claw parts to line up the top edges while gluing, but don't cut out the bottom edges (see Figure 15.1).

Glue up both claws. When the glue is dry, mark the pattern on them again. This will allow you to accurately locate the peg holes in relationship to the lower back edge of the claw so the peg in the wheel will hit the claw. This distance is critical to the proper functioning of the claws. Cut the claws out on the band saw and drill the peg holes. Edge sand all the way around both claws with 80-grit sandpaper. Flat sand both sides of each claw with 80-grit and then 120-grit sandpaper. Edge sand each claw with 120-grit sandpaper and hand sand all the edges with 80-grit and then 120-grit sandpaper.

The Tail

Transfer the tail pattern to $\frac{1}{2}$ " (1.6cm) stock with the grain running from front to back (the back of the tail will be end grain). Cut the tail out on the band saw; edge sand with 80-grit sandpaper. Flat sand with 80-grit and then 120-grit sandpaper. Router the top edge, except the forward (end grain) edge where it will join the body. Edge sand with

120-grit sandpaper. Hand sand any router burns or roughness with 80-grit sandpaper and then hand sand all the edges with 120-grit sandpaper.

The Axle Housing

Cut the $\frac{3}{4}$ " (1.9cm) dowel for the axle housing to length. To drill the axle hole, you'll need to make a simple jig to keep the dowel perpendicular on the drill press. Take a 2x4 that's long enough to clamp securely to the drill press. Put it on edge and drill a $\frac{13}{16}$ " (2.1cm) hole halfway through the center of the board. Now, insert the axle housing dowel into the hole. Clamp the board to the drill press table with the axle housing centered under the $\frac{1}{4}$ " (1cm) bit. You can use pliers with a piece of inner tube as padding to hold the dowel and keep it from spinning as you drill (see Figure 15.2). Drill a little more than halfway through, flip the axle housing over, and repeat the drilling procedure. Hand sand the outside of the dowel if it needs it and round over the ends slightly so they'll go into the arm holes easily.

The Wheels

Prepare the wheels by using the wheel jig (see Toy Making Techniques, Figure 3.9) to drill $\frac{3}{8}$ " (1cm) holes on the inside of the wheels. Cut the

Figure 15.1. Cut out enough of the claw sides to position the spacer, and glue both claw assemblies. This will enable you to position the peg holes perfectly, after the glue is dry.





Figure 15.2. Drill a $\frac{1}{8}$ " (2.1 cm) hole, about $2\frac{1}{2}$ " (6.4 cm) deep, in a middle of a 2x4. Clamp it to the drill press table with the hole centered under the bit. Grip the $\frac{3}{4}$ " (1.9 cm) dowel with a piece of inner tube and pliers as you drill the axle hole through the center.

$\frac{3}{8}$ " (1 cm) work dowels to length, round over the ends, and glue them into place; make sure they're perpendicular to the wheel surface (see Figure 8.3).

Assembly

First, glue in the eye pegs. Then cut four pegs to length using a piece of hardboard (see Toy Making Techniques, Figure 3.5). Round off the ends of the pegs with sandpaper. Spread glue in the peg holes in the arms. Position the claws one at a time and peg them to the arms; use the gauge (see Toy Making Techniques, Figure 3.13) if necessary. While these dry, tap the axle housing almost to the center of the body

with a hammer and a block to avoid damaging the end of the dowel. Then put a little glue around the dowel where it meets the body and drive it the rest of the way into place. Wipe off any excess.

Glue and clamp both claw assemblies onto the ends of the axle housing. Use a scrap under both claws to set the height as you clamp them. Be sure they are set at the same angle (see Figure 15.3). Too high, and the claws will flip too far open and won't close. Too low, and the claws will be hard to lift.

Next, glue and clamp the tail in position. Ream out the $\frac{3}{8}$ " (1 cm) axle hole again to remove any glue squeeze out from the claw assemblies.

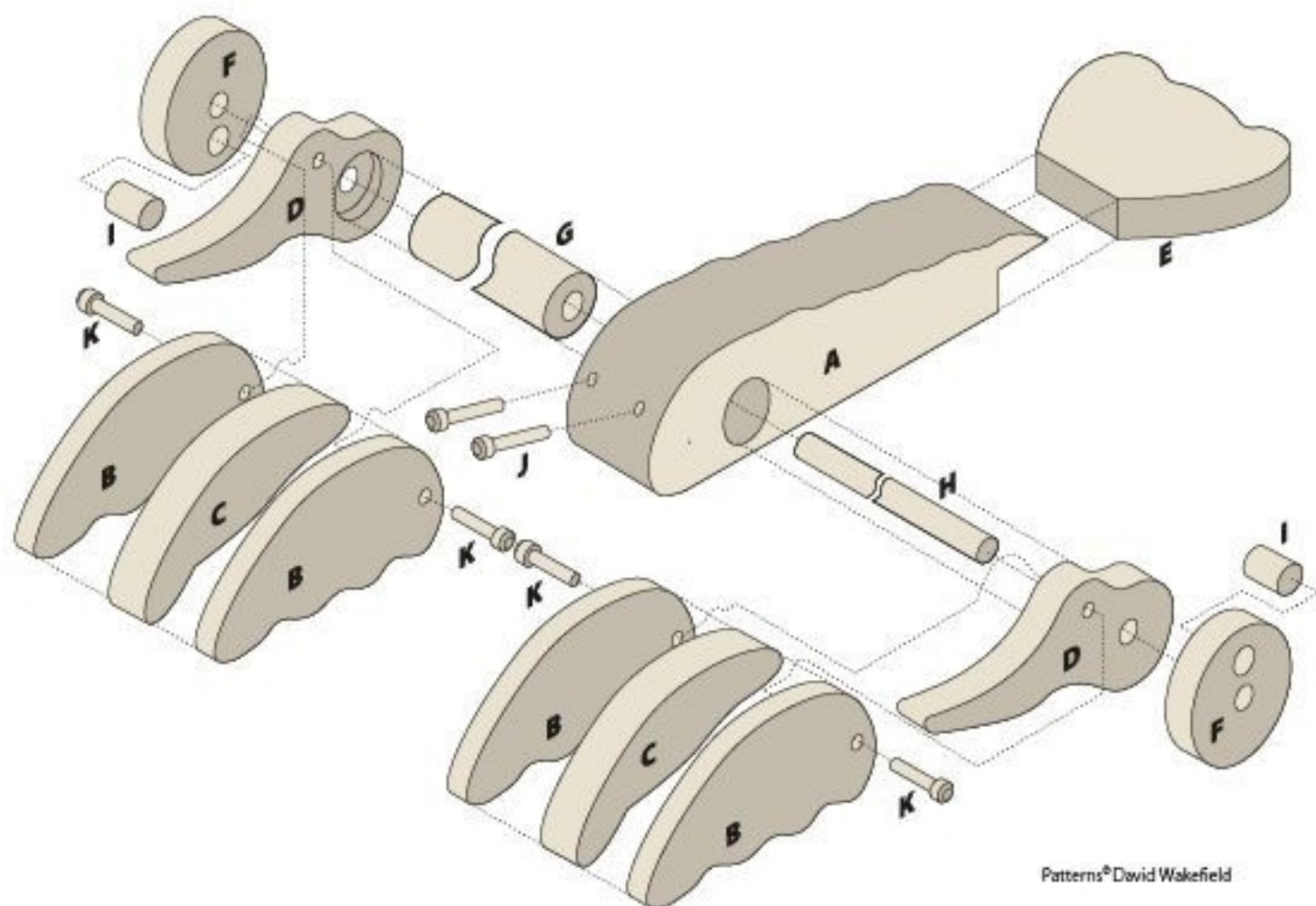
Now, glue the axle to one of the wheels. Position the other wheel so the $\frac{3}{8}$ " (1 cm) pegs are on alternate sides of the axle housing (one above, one below) and tap the second wheel onto the axle. When these are dry, edge sand the axle ends. Roll the lobster and see if the claws are working properly. The relationship between the dowels inside the wheels and the back edge of the claw is critical.

If the claws aren't working perfectly, you can remake the wheels, adjusting the position of the dowel pegs. If the dowel peg is too close to the claw edge, you can move it back, closer to the axle. Be patient. These fine adjustments are sometimes necessary to make sure that such a complex toy works properly.

Once you are satisfied with the action you can let all the glue dry thoroughly, oil him up, and he'll be ready to claw his way into infamy.



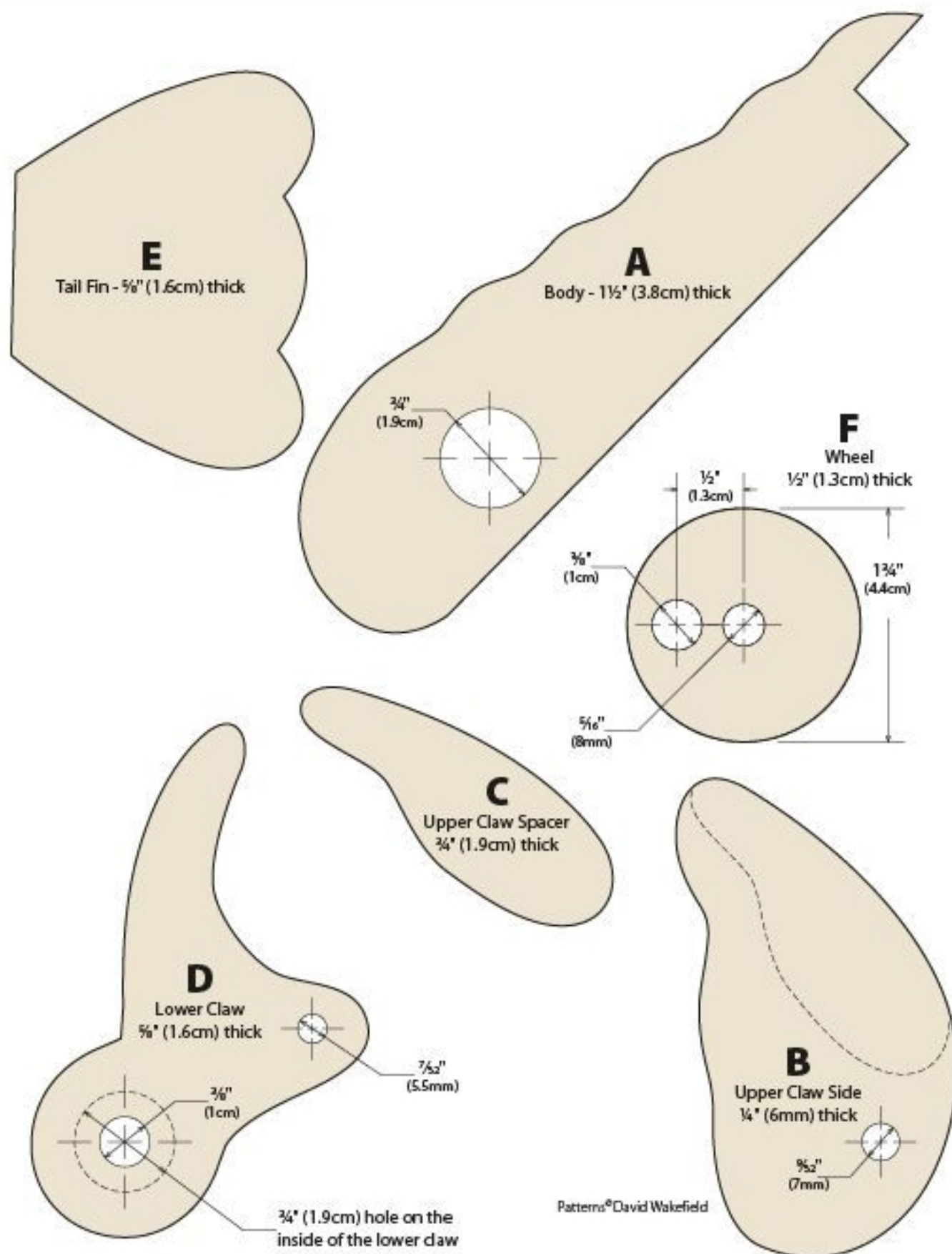
Figure 15.3. Make sure you clamp both claws at the same angle. If they are too high, they'll flop back and won't close again. If they're too low, the dowel pegs won't be able to open them.



Patterns © David Wakefield

Materials

Part	Description	QTY	Thickness	Width or Diameter	Length
A	Body	1	1½" (3.8cm)	1¾" (4.4cm)	6¾" (17.1cm)
B	Upper Claw Sides	4	¼" (6mm)	2" (5.1cm)	3⅞" (9.8cm)
C	Upper Claw Spacers	2	¾" (1.9cm)	1" (2.5cm)	2¾" (7cm)
D	Lower Claws	2	⅝" (1.6cm)	2½" (6.4cm)	4" (10.2cm)
E	Tail Fin	1	⅝" (1.6cm)	3" (7.6cm)	2¼" (5.7cm)
F	Wheels	2	½" (1.3cm)	1¾" (4.4cm)	—
G	Axle Housing	1	—	¾" (1.9cm) diameter	3⅞" (9.8cm)
H	Axle	1	—	⅝" (8mm) diameter	5⅞" (14.9cm)
I	Wheel Plugs	2	—	¾" (1cm) diameter	¾" (1.9cm)
J	Eyes	2	—	⅞" (5.5mm) diameter	¾" (1.9cm)
K	Pegs	4	—	⅞" (5.5mm) diameter	⅝" (1.6cm)



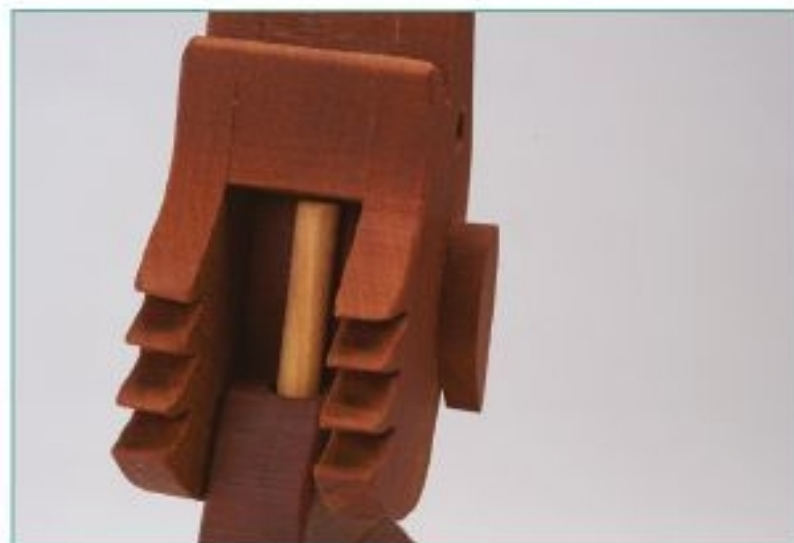
16 Wild Wolf

The wolf has a special place for me, as it was the animal that inspired the beginnings of my original business, Howling Wolf Woodwork, thirty-five years ago. This fellow has some very small parts as well as some rather challenging detail on the face. The result, however, is a pretty cool creature. The classic howling action is accomplished by a cam between the front legs that lifts a drive dowel as the axle rotates.

The Body

Lay out the body on 1½" (3.8cm) stock. Drill the pivot hole, which will be covered by the ear, and the axle holes. Be sure to draw the line on the side to locate the drive dowel hole for drilling. I cut the dado slot between the front legs before I cut out the silhouette so I have a stable base when I rest the piece on the table saw. Set the height of the dado for half the height of the slot; set the width of the blades for half the width of the slot. Mark the table with a pencil where the cut will end and mark the side of the wolf body blank, so you don't cut too far on the table saw (see Figure 16.1). Move the fence and cut the second half. Now, raise the blades to the full height of the cut, make a new pencil mark on the table to show the end of that cut, and repeat the process. You can also cut this slot with two saw cuts with a back saw and then chisel out the scrap.

Once the slot is done, cut out the silhouette on the band saw. Next, you can clamp the body to a simple jig on the drill press to drill the hole for the drive dowel (see Figure 16.2). The dowel hole is at a right angle to the bottom of the legs so the piece will sit at the right angle on the drill press when you drill the ¾" (1cm) hole. Use a Forstner bit to avoid wandering.



The drive dowel, inserted through a hole in the Wolf's body, lifts and lowers the head.



The cam wheel, mounted on the front axle, lifts and lowers the drive dowel.



The Wolf's front wheels are attached using a standard axle assembly.



Figure 16.1. Make a pencil mark on the table of the table saw showing where the blade meets the table. That's where you will end the cut.

Now, cut out the silhouette on the band saw, and edge sand with 80-grit and 120-grit sandpaper. Flat sand both sides of the body with 80-grit and 120-grit sandpaper and router the entire silhouette. Hand sand the routed edges with 80-grit and 120-grit sandpaper to remove any burns and roughness.

The Head

Lay out the two matching sides and cut them out very carefully. Use a scroll saw for an accurate job. Lay the sides on top of each other to drill the eye and pivot holes so they are identical. Edge sand the back of the head pieces and the fur rough of the neck, as it will be hard to sand these accurately once the head is assembled. Lay the spacer out on a larger block so you have something to hold on to as you make the last cut (see Figure 16.3).

Put some glue on both sides of the spacer and position the assembly as carefully as possible as you clamp the head sides in place. When the assembly is thoroughly dry, edge sand the parts of the head where the spacer meets the edges. Use a light touch and go slowly. You may want to use a rat tail file for the mouth. Then, break the edges by hand with 120-grit



Figure 16.2. Use a simple jig made of two boards glued together at a right angle to hold the body firmly in a vertical position as you drill the hole for the drive dowel.



Figure 16.3. Lay out the spacer with a big piece to hold on to so you can keep your fingers away from the blade on the band saw or scroll saw.

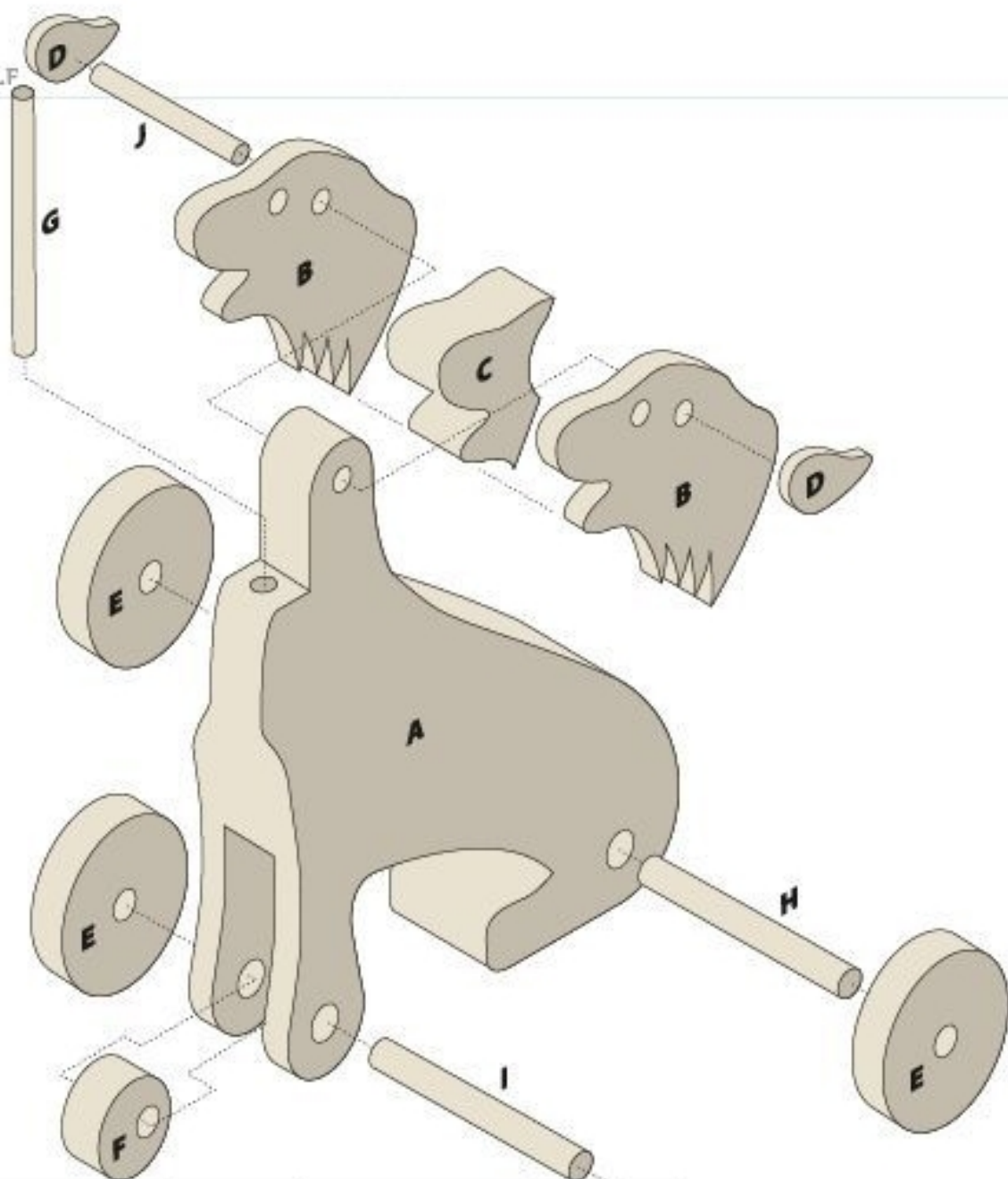
sandpaper. Cut the ears out of $\frac{1}{4}$ " (6mm) stock using a scroll saw or a coping saw and sand the edges and surfaces by hand with 120-grit sandpaper. Break the edges gently.

Assembly

Make the cam with a hole saw. Plug the axle hole and drill a new one as shown in the drawings. If you make the hole $\frac{1}{64}$ " (0.4mm) oversized ($\frac{21}{64}$ " [8.5mm]), the axle will pass through more easily and prevent the cam from splitting during assembly. Cut the axles to length and hand sand the ends to break the edges. Glue on one wheel and slip the axle through the back of the body; glue on the other wheel. Repeat this process for the front axle, but slide the axle through the cam on its way through the slot. With the wolf on its back, drill a $\frac{1}{16}$ " (2mm) hole through the cam and the axle and pin it with a toothpick and glue. Saw off the end and sand it flush to the cam's surface. When the glue has set up, edge sand the ends of the axles.

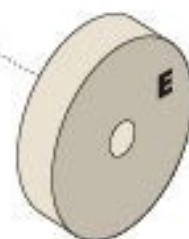
Cut the $\frac{1}{4}$ " (6mm) dowel to length—slightly longer than the width of the head—and hand sand both ends to break the edges. Position the head with the holes lined up and slide the dowel through until it starts to enter the hole on the second side. Put a little glue on the outside of the protruding dowel and on the inside of the hole on the far side. With the head lying flat on wax paper, tap the dowel home. Flat sand both sides of the head (with the grain) to smooth the ends of the dowel. Glue and clamp the ears in place with a small clamp; be careful to cover the dowel and to keep the ears parallel to each other.

Lastly, cut the drive dowel to length, round both ends with sandpaper, and slip the dowel in place. Push the wolf along and make any adjustments to the length of the dowel (including making it over if necessary). When you are satisfied with the movement, it's time to oil this fellow and let him loose on the full moon!

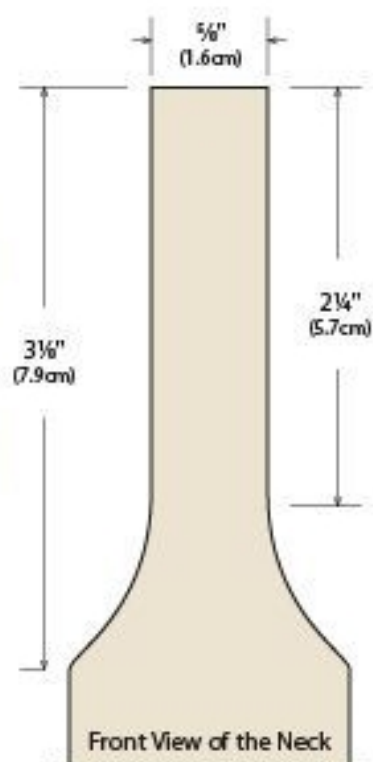
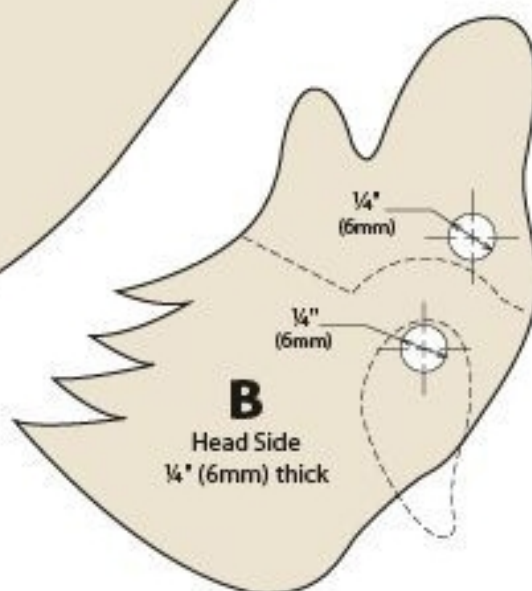
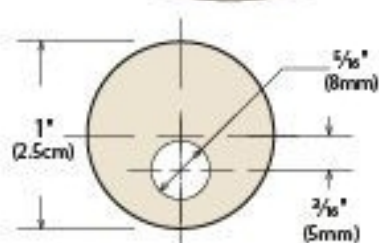
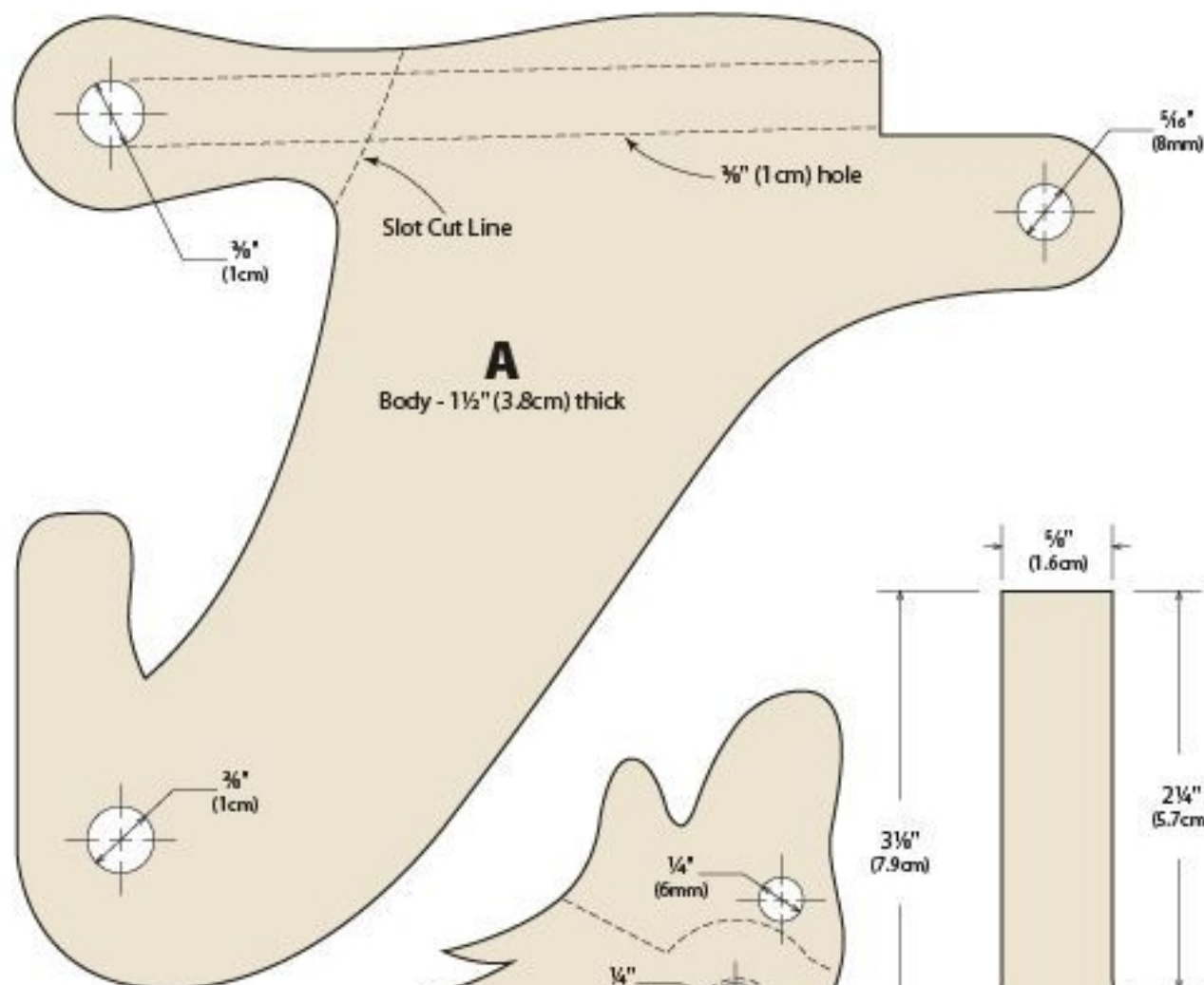
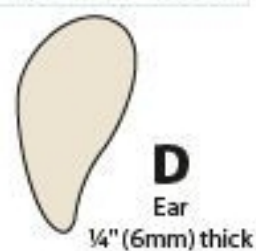
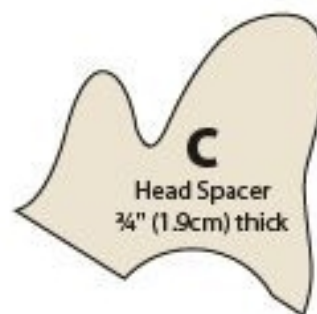
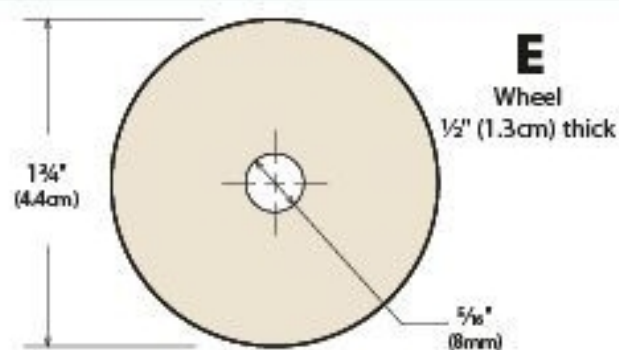


Materials

Part	Description	QTY	Thickness	Width or Diameter	Length
A	Body	1	1½" (3.8cm)	5½" (14cm)	6½" (16.5cm)
B	Head Sides	2	¼" (6mm)	2" (5.1cm)	3½" (8.9cm)
C	Head Spacer	1	¾" (1.9cm)	1¾" (4.4cm)	1¾" (4.4cm)
D	Ears	2	¼" (6mm)	⅝" (1.6cm)	1¼" (3.2cm)
E	Wheels	4	½" (1.3cm)	1¾" (4.4cm) diameter	—
F	Cam Wheel	1	½" (1.3cm)	1" (2.5cm) diameter	—
G	Drive Dowel	1	—	⅝" (8mm) diameter	4¼" (10.8cm) (approximately)
H	Rear Axle	1	—	⅝" (8mm) diameter	2⅝" (6.7cm)
I	Front Axle	1	—	⅝" (8mm) diameter	2⅝" (6.7cm)
J	Head Dowel	1	—	¼" (6mm) diameter	2⅞" (5.4cm)



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17 Timid Turtle

This is one of my earlier designs and also one of my favorites. On the surface it appears to be quite a bit of work to make. However, the simplicity of the working mechanisms (and the solid construction) ensures that it will work smoothly for years. It will give a great deal of pleasure to generations of children.

As with several of the toys you'll find on my website, this turtle design was in my first book. I have, however, made some significant changes. I shrank it down a bit for starters. The smaller size is much lighter for a child to carry from the toy box to the floor, and I think it makes for a friendlier, more intimate toy.

The Shell Pieces

When you're choosing a piece of wood for the shell, remember that this toy is going to take a bit of work, so you may want to choose something special. The angles of the shell will accentuate the grain patterns.

Lay out the pattern for the shell so the grain runs lengthwise on the piece of wood you've chosen. Transfer the pattern to the bottom of this piece.

Tilt the band saw table to 40 degrees. Cut the shell out very carefully, following the lines *exactly*. Keep the lines perfectly straight or you will distort the octagonal shape of the shell when you sand the sides flat.

These next two cuts are the most difficult, so take special care.

Transfer the pattern for the head and tail holes onto the shell. Leave the table set at 40 degrees and cut out these holes using a sharp blade (see Figure 17.1). I use a $\frac{1}{8}$ " (3mm) blade for added control.

The trickiest part of the cut is the last half of the curve, from the top of the arc to the end of the cut. To successfully execute this cut, you have to anticipate the curve and stay ahead of it. In other words, turn the piece beyond the cutting line as you go. You might want to try this cut on a scrap before you go for the shell.

The next step is to flat sand all the surfaces, including the top and underside, on the stationary belt sander with 80-grit sandpaper. Do this very slowly, looking at the surfaces often to make sure you aren't deviating from the actual sawn surface. Sand slowly, with a light touch.

The front and rear surfaces, where the head and tail come out, need a little more attention. Left as they are, they will be too thin where they meet the



All four wheels are hidden underneath the Turtle in the space between the leg pieces.



The inner drive axles, mounted in off-center holes in the wheels, cause the Turtle's head and tail to move in and out of the shell.



The angles cut around the shell base and top give the Turtle a realistic appearance.



Figure 17.1. This is a difficult cut, so use a sharp $\frac{1}{8}$ " (3mm) blade and take your time. Once you pass the top of the arc, anticipate the curve and try to keep ahead of it as you saw or you'll be forced off the line.



shell base. Holding these surfaces flat on the belt sander, rock the shell toward you and away from you, smoothly, to slightly round the bottom where it will meet the shell base (see Figure 17.2).

Repeat the entire belt sanding process with 120-grit sandpaper. Don't bother with 120-grit on the underside of the shell. Now, hand sand all the corners with 120-grit sandpaper as well.

Now, on to some easier steps. To make the shell base, I think it's easiest to cut a board to the rectangular dimensions of the shell base by ripping and crosscutting. Then, lay out the pattern and simply cut the corners off on the band saw or scroll saw.

Drill the marked holes in the inside corners to make sawing easier. Next, using a band saw, cut

straight in to the end of the shell base in the center and cut out the scrap.

If you have a scroll saw, you can feed the blade through one of the corner holes, reattach it, and cut away the scrap without compromising the outer edge of the piece.

If you used a band saw, glue and clamp the slot closed again.

When the glue has thoroughly set up, flat sand the shell base with 80-grit sandpaper.

Now, sand all the outside edges on the stationary belt sander, being careful to hold it perfectly vertical. Check the surfaces often to avoid distorting the octagonal shape. A smooth sweep around each corner as you go will gently round the corners of the octagon (see Figure 17.3).



Figure 17.2. To round over the bottom of the head hole and tail hole sections of the shell, hold these surfaces lightly on the belt sander, one at a time, and rock them smoothly toward you and away from you.

Repeat the whole sanding process with 120-grit sandpaper and then router all the edges, inside and out, top and bottom. Lastly, hand sand all the routed edges.

The Head and Tail

Transfer the patterns for the head and tail to wood that will complement the shell.

Drill the holes in the head and tail. Now, cut out the head and tail. Edge sand and then flat sand the head and tail with 80-grit and then 120-grit sandpaper. Round all the edges slightly by hand with 100-grit or 120-grit sandpaper.



Figure 17.3. Holding the shell base vertically on the belt sander, sweep around each corner to gently round them.



Figure 17.4. Hold the foot piece firmly, resting the cut-off corner on the band saw table as you cut the curve on the top of each foot.

The Foot Pieces

Cut out the two blocks for both foot pieces with the corners cut off, making sure that the diagonal cuts are straight as they will support the pieces on the band saw table to make the curved cuts on the top of the feet. Next, transfer the pattern to the shorter edge (the edge with the bevel missing) of both pieces to locate the axle holes. Drill the $\frac{3}{8}$ " (1cm) holes to a depth of 1" (2.5cm).

Now, transfer the curved feet pattern to the longer edge of both pieces. Put the foot piece on its edge on the band saw or scroll saw table with the removed corner sitting on the table (see Figure 17.4).

This sets the angle for the cut removing the top of each foot. Cut with a nice smooth sweep. Sand this edge on the edge sander in the same fashion with 80-grit and 120-grit sandpaper (see Figure 17.5).

A half-circle platen behind the sanding belt will help greatly with this kind of inside curve. I use half of a 1" (2.5cm) dowel and just keep it on there.



Figure 17.5. Sand the curved cut the same way you cut it out.

The last cut is the final silhouette cut. This is a bit tricky. Lay out the pattern on the bottom surface of each foot piece. Now, flip them over and cut them out on the band or scroll saw, holding them very firmly and cutting slowly, as the feet are unsupported. Next, you can flip those pieces back, right side up, to edge sand that cut with 80-grit and 120-grit sandpaper.

Break all the edges with 120-grit sandpaper and the feet are done.

The Wheels

Lay out the placement of the $\frac{3}{16}$ " (8mm) holes on the inside of the four $1\frac{1}{4}$ " (4.4cm) wheels for the head and tail assemblies.

Assembly

Cut the four $\frac{3}{8}$ " (1cm) outer drive axles to length. With waxed paper on the workbench, lay the four wheels out with the outside of the wheels facing up. Spread glue in the inner axle hole and drive home the $\frac{3}{8}$ " (1cm) dowels. When the glue is dry, use the flat sander to remove glue from the inside of the wheels.

Cut the two inner drive axles to length. Spread glue in the hole on the inside of one of the wheels that you just doweled. Be especially careful not to put too much glue in the hole or it will prevent the dowel from seating properly.

Use the edge of the workbench for support under the wheel as you drive the dowel in as far as you can. Make sure that this dowel is square to the

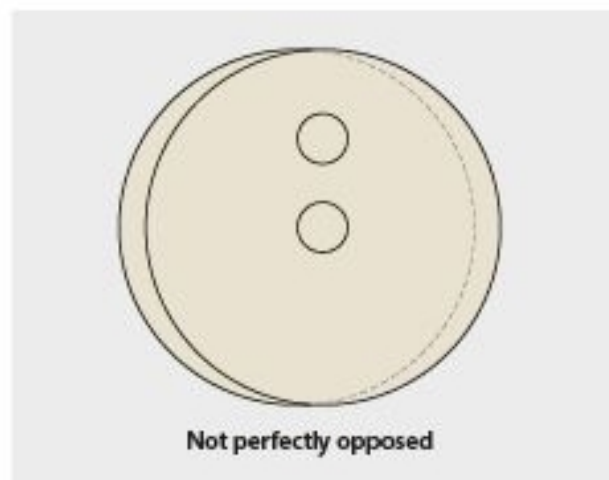


Figure 17.6. Make sure the wheels are directly opposite each other.

wheel surface and parallel to the dowel sticking out through the center of the other side of the wheel.

Leave the wheel on the edge of the workbench and slip the Turtle's head onto the offset axle you just glued. Spread glue in the hole on another wheel. Locate this second wheel so the axle starts into the hole and the two wheels are positioned in perfect opposition. Now, hammer the wheel onto the axle, again being careful the wheel is perpendicular to the axle. Look over the assembly before it dries. It is essential that this assembly be strong and true for the proper functioning of the Turtle and to ensure its long life (see Figures 17.6 and 17.7).

Look at the front and see if the wheels are parallel; adjust accordingly. Look at the side and see if the wheels are directly opposed to each other;

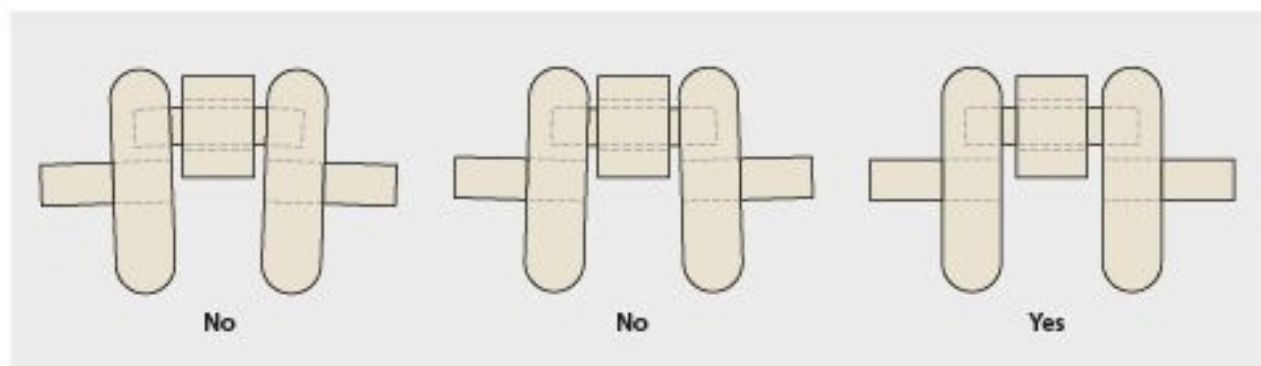


Figure 17.7. The wheels should also be perfectly parallel.

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Figure 17.8. Drill these holes at a compound angle toward the side and back.

make any adjustments necessary. Now, roll the assembly on the workbench. If it rocks or waddles at all, the wheels still aren't perfectly opposed. Give them a little twist and try again.

If the two protruding axles aren't spinning in a straight line, with no up or down motion, then the wheels still aren't parallel. Adjust them by hand or by tapping them with a hammer. When you're sure the assembly is perfect, repeat the entire procedure for the tail assembly.

I like to put the whole assembly together at this point—without any glue—to see if I have any problems. If you need to, you can still remove material (with a four-in-hand rasp) from the ends of the shell base or inside the curved head and tail openings in the shell.

Once you have the assembly working smoothly, you can glue the head and tail assembly to the shell base. I put the shell base in the vise. Make sure the head and tail are facing the right way and put glue on the feet assemblies, working it away from the edges to avoid squeeze out. Clamp the assembly in place, making sure the head and tail face downward and go through the shell base and that the foot pieces are perfectly parallel and centered from front to back. Check once again for smooth movement without any interference and make any necessary adjustments.

When the assembly is dry, place the shell on top and check for free movement once more. If all is well, glue and clamp the shell in place.

The Cord

Clamp the turtle head-up in the wood vise with the top of its head facing you. Use an awl or center punch and tap two small holes where the cord holes will be drilled. With a $\frac{1}{4}$ " (6mm) brad point bit in the electric drill, use these holes to position the drill bit and drill the cord holes. These holes are drilled at an angle toward the back and the sides (see Figure 17.8). Check the top and side views to get the angle right.

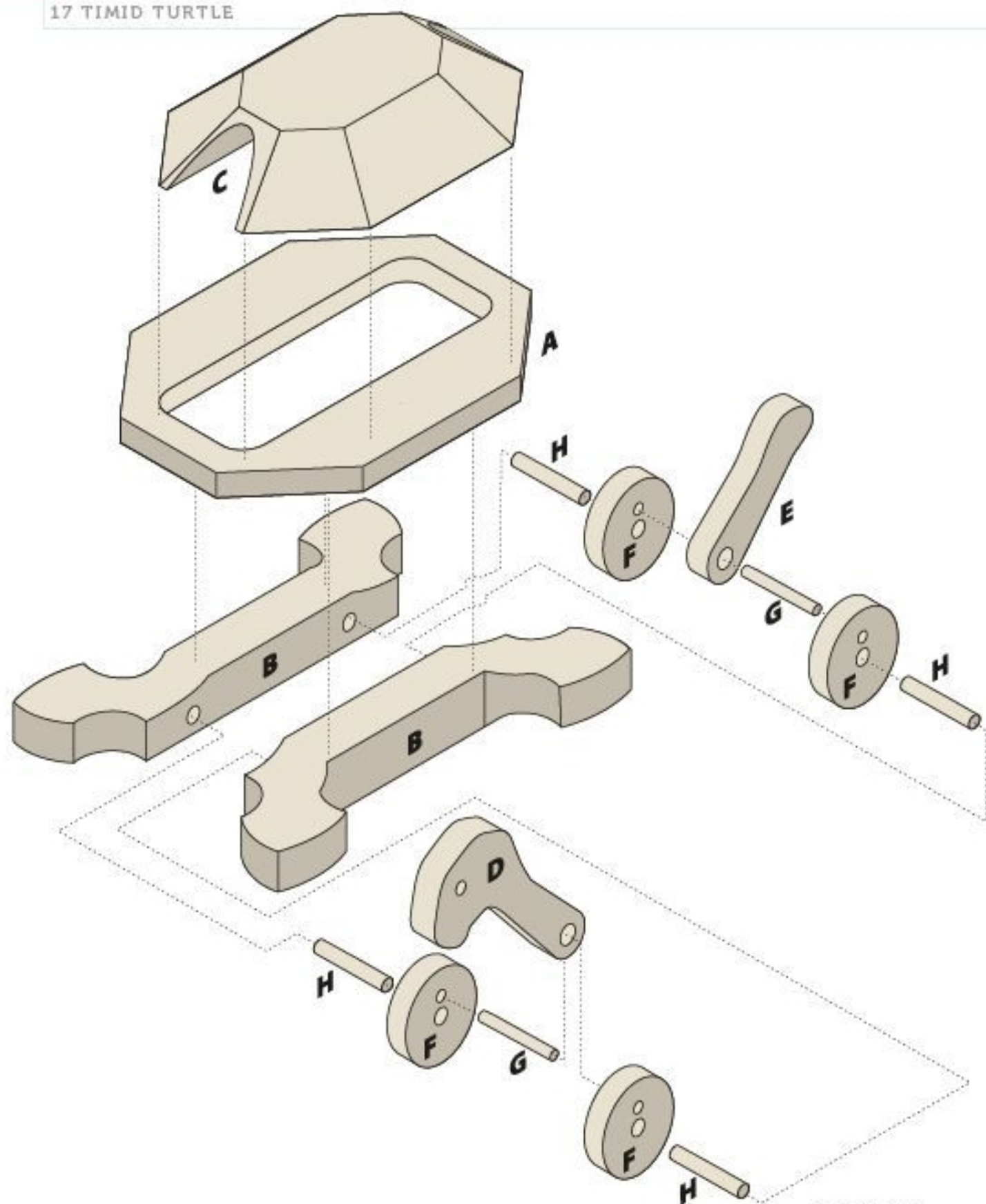
Now is the time to oil the Turtle to avoid getting oil on the pull cord. I use mineral oil (baby oil). It is nontoxic and gives the wood a good bit of protection. It can be easily reapplied at any time.

When the finish has been absorbed, feed the cord through both holes from the top. Tie an overhand knot on both ends of the cord and pull it tight. Make a loop in the middle of the cord and attach a second cord with a bowline knot (see Figure 17.9).

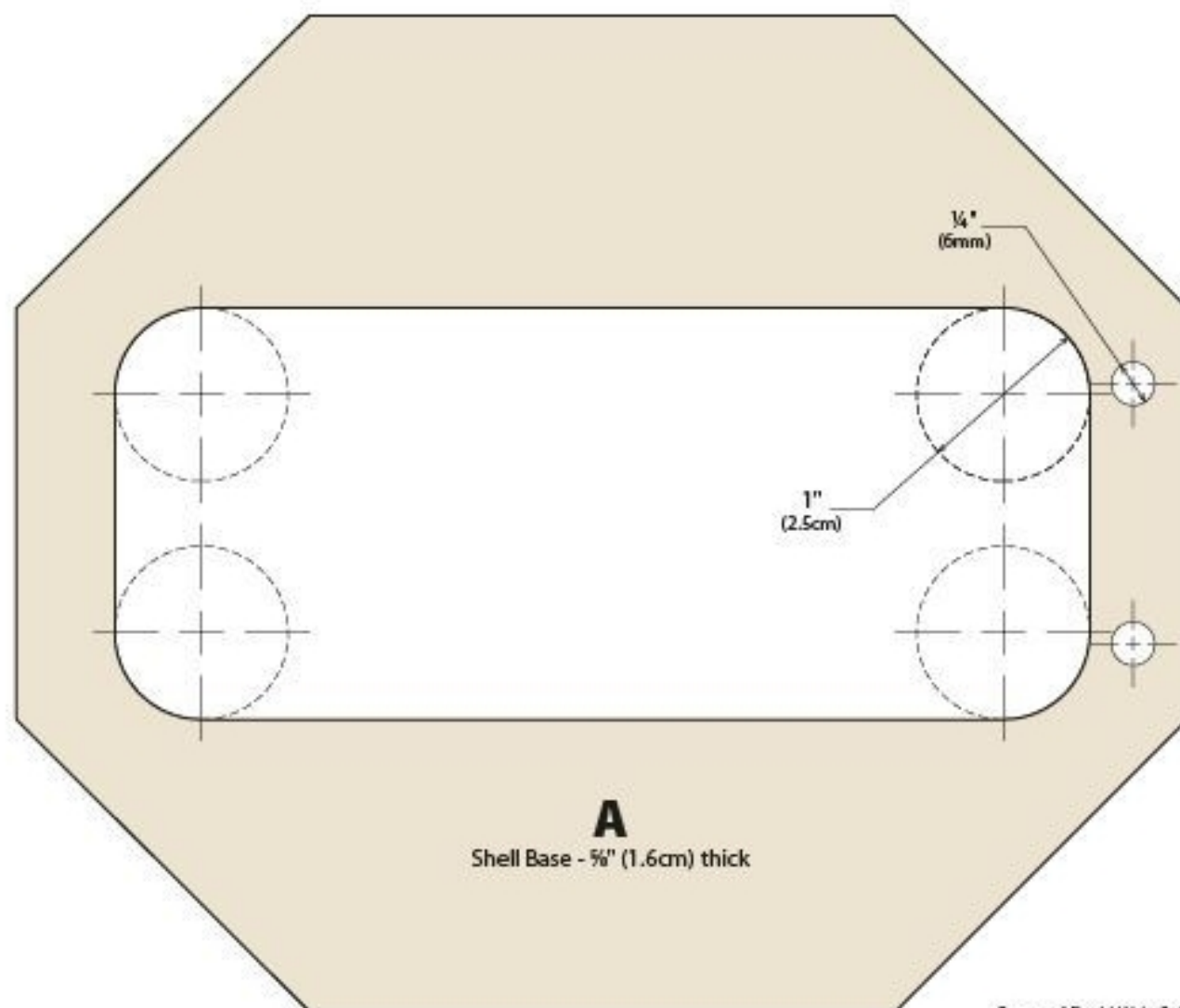
Adjust this knot until it is perfectly centered. Attach the bobble with an overhand knot, and there you are. This timid creature may have been difficult to make, but I'm sure you'll think it was well worth the effort when you watch a small child playing with it.

Figure 17.9. Make a loop in the center of the pull cord (J), and attach the pull cord yoke (I) to it with a bowline knot.





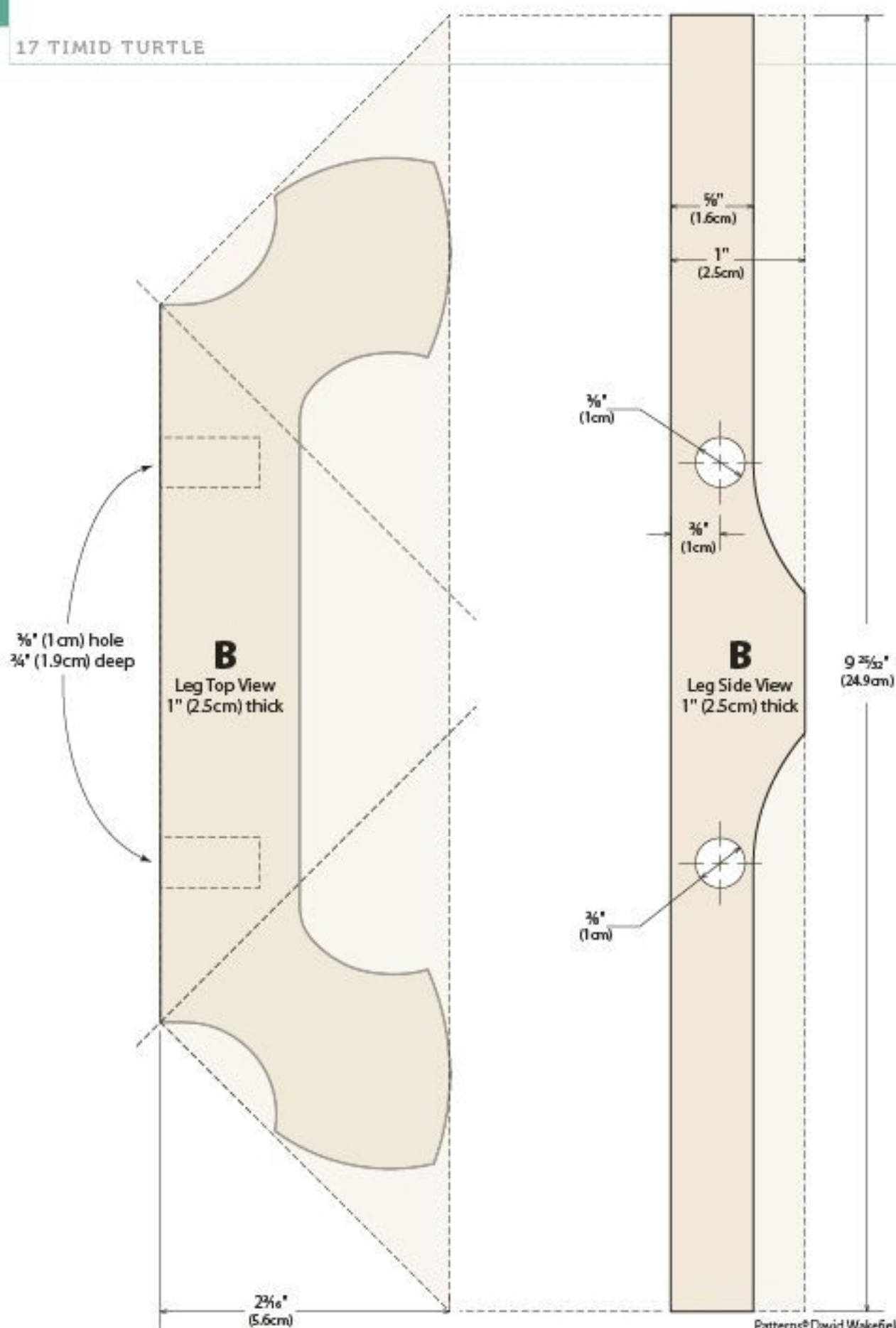
Patterns © David Wakefield



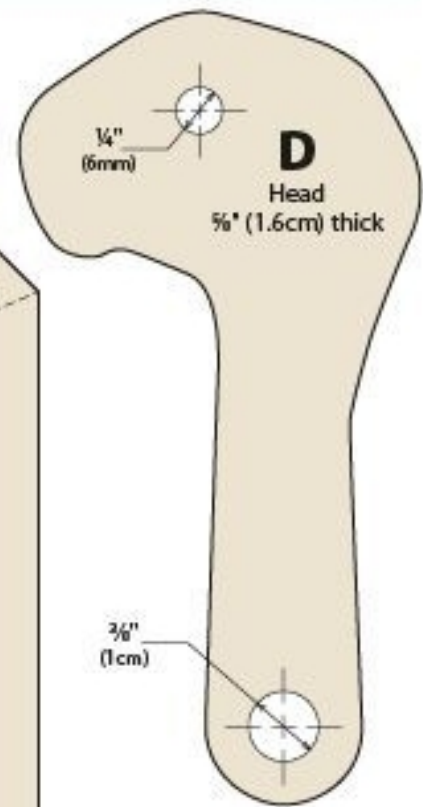
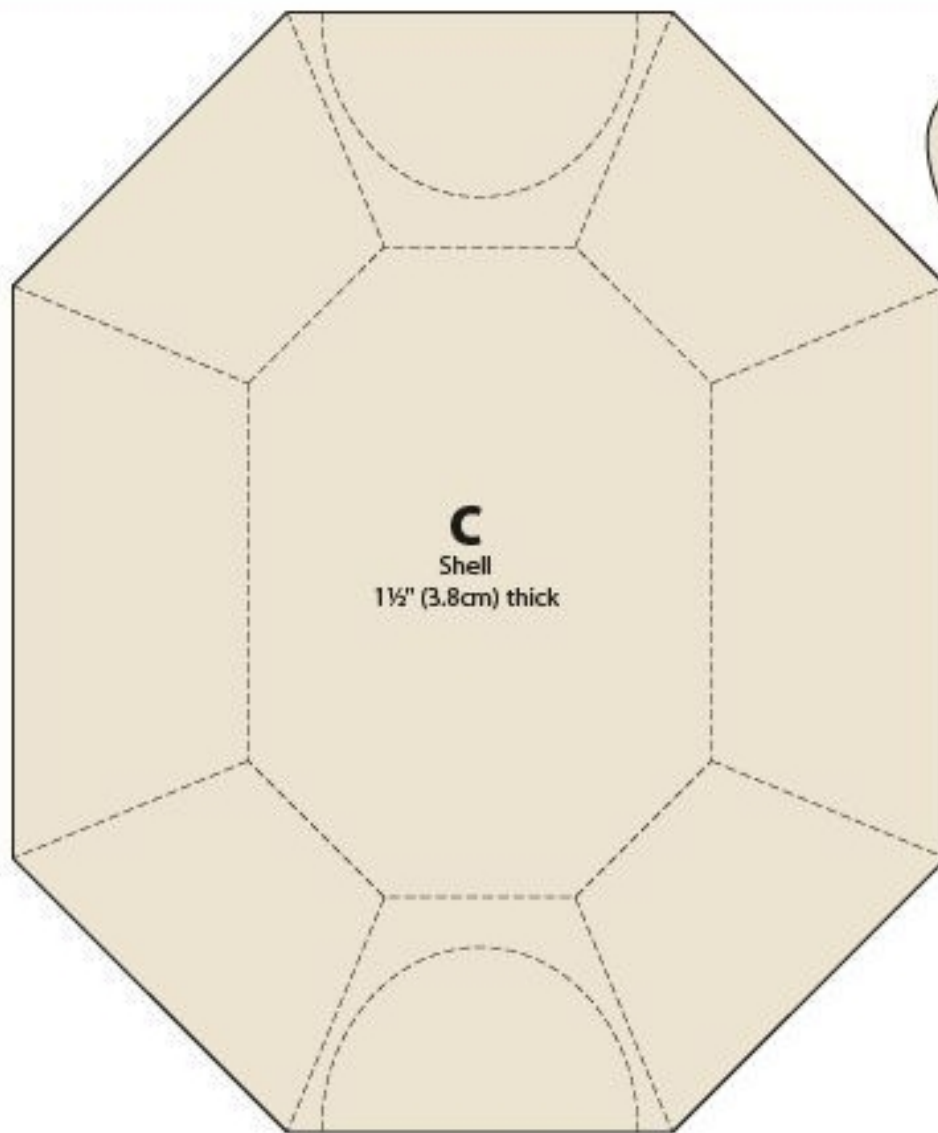
Patterns © David Wakefield

Materials

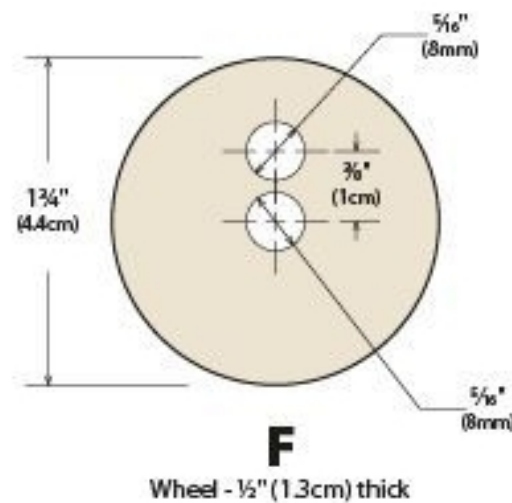
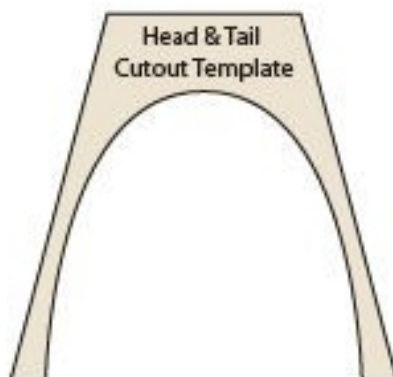
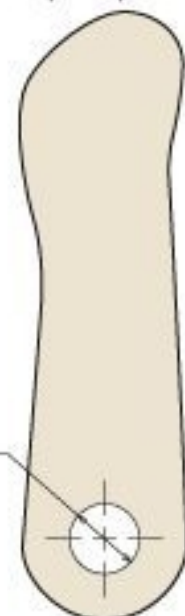
Part	Description	QTY	Thickness	Width or Diameter	Length
A	Shell Base	1	$\frac{5}{8}$ " (1.6cm)	$5\frac{3}{4}$ " (14.6cm)	$6\frac{3}{4}$ " (17.1cm)
B	Legs	2	1" (2.5cm)	$2\frac{1}{4}$ " (5.7cm)	$9\frac{5}{8}$ " (25.1cm)
C	Shell	1	$1\frac{1}{2}$ " (3.8cm)	5" (12.7cm)	6" (15.2cm)
D	Head	1	$\frac{5}{8}$ " (1.6cm)	$2\frac{1}{4}$ " (5.7cm)	$4\frac{1}{2}$ " (11.4cm)
E	Tail	1	$\frac{5}{8}$ " (1.6cm)	1" (2.5cm)	$3\frac{5}{8}$ " (9.2cm)
F	Wheels	4	$\frac{1}{2}$ " (1.3cm)	$1\frac{3}{4}$ " (4.4cm)	—
G	Inner Drive Axles	2	—	$\frac{5}{16}$ " (8mm) diameter	$1\frac{3}{4}$ " (4.4cm)
H	Outer Drive Axles	4	—	$\frac{5}{16}$ " (8mm) diameter	$1\frac{1}{4}$ " (3.2cm)
I	Pull Cord Yoke	1	—	$\frac{1}{4}$ " (6mm) diameter	8" (20.3cm)
J	Pull Cord	1	—	$\frac{1}{4}$ " (6mm) diameter	28" (71cm)
K	Pull Card Ball	1	—	1" (2.5cm) diameter	—



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E
Tail
5/8" (1.6cm) thick



Patterns © David Wakefield

18 Happy Hound

The combination of the appearance and the movement of this toy makes it a true classic. The feet, which are pegged to alternate sides of the front wheel, make the Hound trot along as he's pulled.

The feet also push forward on the ears as they pass, lifting the head and giving it that wonderful sniffing motion. The spots are an extra that give the Hound the look of a blue tick hound.

The Body

The body can be made out of almost any wood. It doesn't have any critically weak areas or any need to be particularly heavy or light.

Transfer the body pattern to a suitable piece of wood and drill all the axle and peg holes. Cut out the body on the band saw. Use blocks and clamps to position the body on the drill press table and drill the pull cord holes. Before you drill the tail hole, cut out the leather for the tail with a mat knife and wrap it around a $\frac{3}{8}$ " (1cm) dowel. You will now be able to determine what size hole you'll need to fit the tail and the $\frac{3}{8}$ " (1cm) dowel plug snugly (see Figure 18.1). The hole size will vary according to the thickness of the leather you use (the stiffer the leather, the better). Now, drill the hole.

Edge sand the body with 80-grit sandpaper. Flat sand the body with 80-grit and then 120-grit sandpaper. Router all the edges and edge sand with 120-grit sandpaper. Hand sand all the routed surfaces with 80-grit and then 120-grit sandpaper.

The Legs and Feet

Transfer the patterns for all the leg pieces to a moderately strong piece of wood that will go well with the body. Drill all the axle and peg holes.

Cut the parts out on the band saw. Edge sand and then flat sand all the parts with 80-grit and 120-grit sandpaper. Then, hand sand the roughness off all the edges of the front leg parts with 120-grit sandpaper. Now, cut the hind legs with a router and sand them with 80-grit and 120-grit sandpaper.

Peg the front legs in alternate sets, using a clearance gauge (see Toy Making Techniques, Figure 3.13) if necessary. When they're dry, sand off the back of each set to remove any dried glue.



The Hound's front feet move forward and backward as the wheels turn, pushing against the back of the ears and lifting the nose.



The Hound's back wheels are attached using a standard axle assembly.



The leather tail is an extra touch that helps bring the Hound to life.

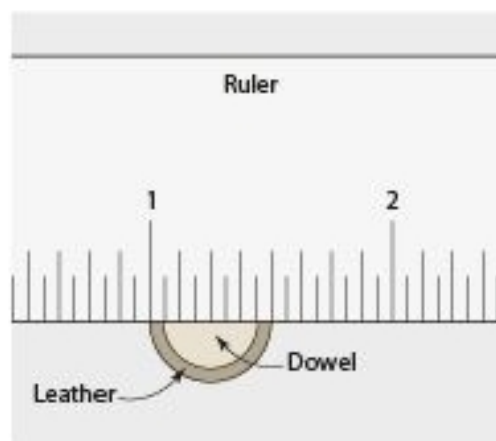


Figure 18.1. Wrap the leather for the tail around a $\frac{3}{8}$ " (1cm) dowel and measure the diameter to see how big to make the hole. Make the hole just a bit smaller than the actual diameter in order to hold the tail firmly in place.



Figure 18.2. Use this template to position the ears as you glue them one at a time.

The Head

Lay out the head sides on $\frac{1}{2}$ " (1.3cm) stock. Drill the eye holes carefully with a brad point bit so they are identical and cut them out with care. Again, they need to match for the head to work well.

Edge sand back to the pattern line on both pieces with 80-grit sandpaper and repeat with 120-grit sandpaper. Now follow the same procedure without the drilling for both ears. Cut the spacer out of $1\frac{1}{8}$ " (4.8cm) material and edge sand the area that will be inaccessible after assembly. Smooth out the transition areas. Now, glue the spacer and the two head sides together using the gluing jig (see Toy Making Techniques, Figures 3.14, 3.15, and 3.16). When the glue is dry, edge sand with 80-grit and 120-grit sandpaper. Flat sand the outsides with 80-grit and then 120-grit sandpaper. Make sure to remove any dents from clamping. Hand sand all the edges with 120-grit sandpaper.

To attach the ears, make a template (out of hardboard or plywood) of the head with the overlap of the ears removed (see Figure 18.2). Cut this out very carefully. Now using this template, glue on the ears one at a time, making sure they are perfectly opposed to each other.

The Wheels

Drill peg holes in both the front and rear wheels as in the pattern.

Assembly

Peg the head to the body using the clearance gauge (see Toy Making Techniques, Figure 3.13). Now, glue one wheel on the axle. Slip it through the body and glue on the second wheel. Make sure that the peg holes are diagonally opposed so one foot will be forward when the other is back. Set the wheels as close to the body as possible so they will fit inside the ears and let the head fall all the way down between sniffs. If they won't fit, file away some of the inside of the ears until they do.



Figure 18.3. Leave extra material around the back of the template so it won't break. Use the template to line up the first hind leg, and then line up the second leg perfectly with the first. Make sure the axle is square and spins freely, and then clamp the legs, using pads or scraps to protect the surface of the legs.

The Front Legs

Peg both shoulders to the body using the clearance gauge. Peg the feet to the wheels; use the edge of the workbench to support the wheels as you drive in the pegs. Carefully wipe any excess glue off the inside of the wheels before it gets smeared on the body. To determine the rear axle length, position the rear legs and measure the total distance across both feet, add the thickness of both wheels plus $\frac{1}{8}$ " (3mm) clearance, and cut the rear axle to that length.

Attach the rear axle to one of the rear wheels. Run the dowel through both rear feet and glue on the second wheel. When the glue is dry, edge sand the dowel ends.

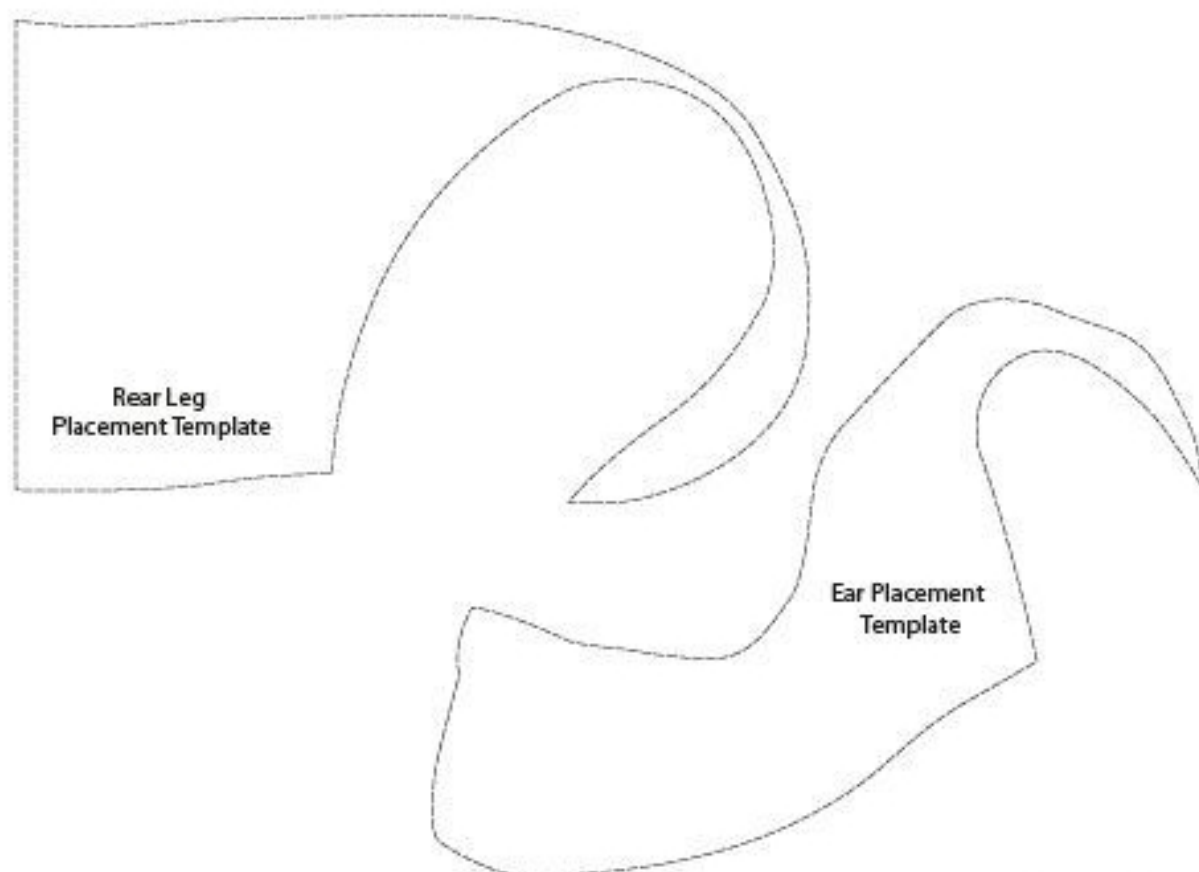
The Rear Legs

To attach the rear legs, you need to make a template similar to the one used to position the ears. Cut out the shape of the rear of the body with the rear leg overlap removed. Leave a little extra around the back so the template won't break (see Figure 18.3). Now, glue and clamp the rear legs using the jig you've made to align them properly. Make sure the nose is just off the ground as you glue the legs or it will rub the floor when it's finished. Check to be sure the axle is perpendicular and allows the wheels to spin freely.

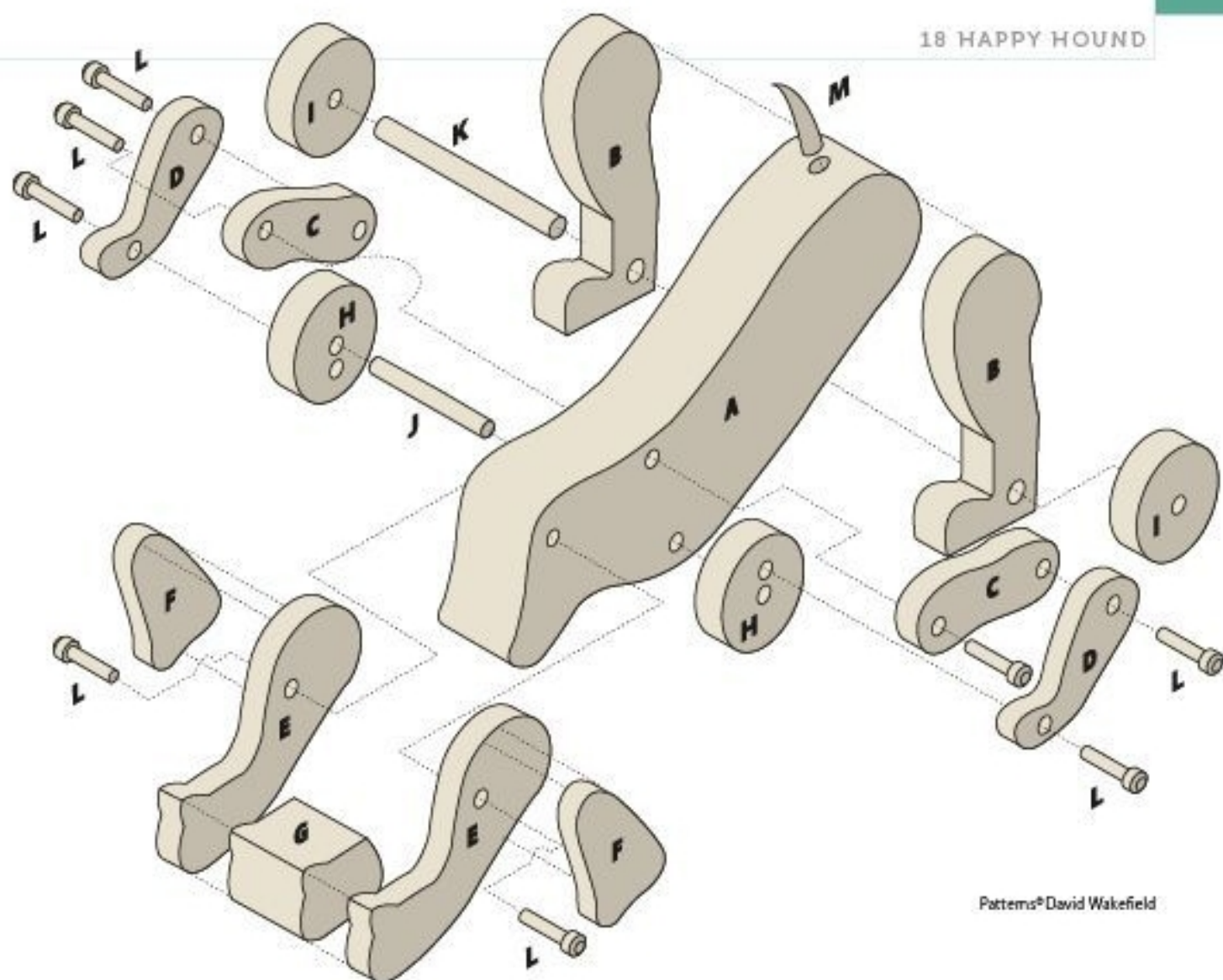
The Tail

Spread glue in the tail hole. Next, spread glue $\frac{3}{4}$ " (1.9cm) up from the bottom of the tail leather, inside and outside. Roll up the leather and place it in the tail hole. Carefully place the $\frac{3}{8}$ " (1cm) plug inside the leather in the hole. Now drive the plug home using another piece of $\frac{3}{8}$ " (1cm) dowel to avoid squishing the leather with the hammer. When you oil the Hound, don't get oil on the tail or it will get stiff when the oil dries.

Now attach the pull cord and there you go. A child's best friend!



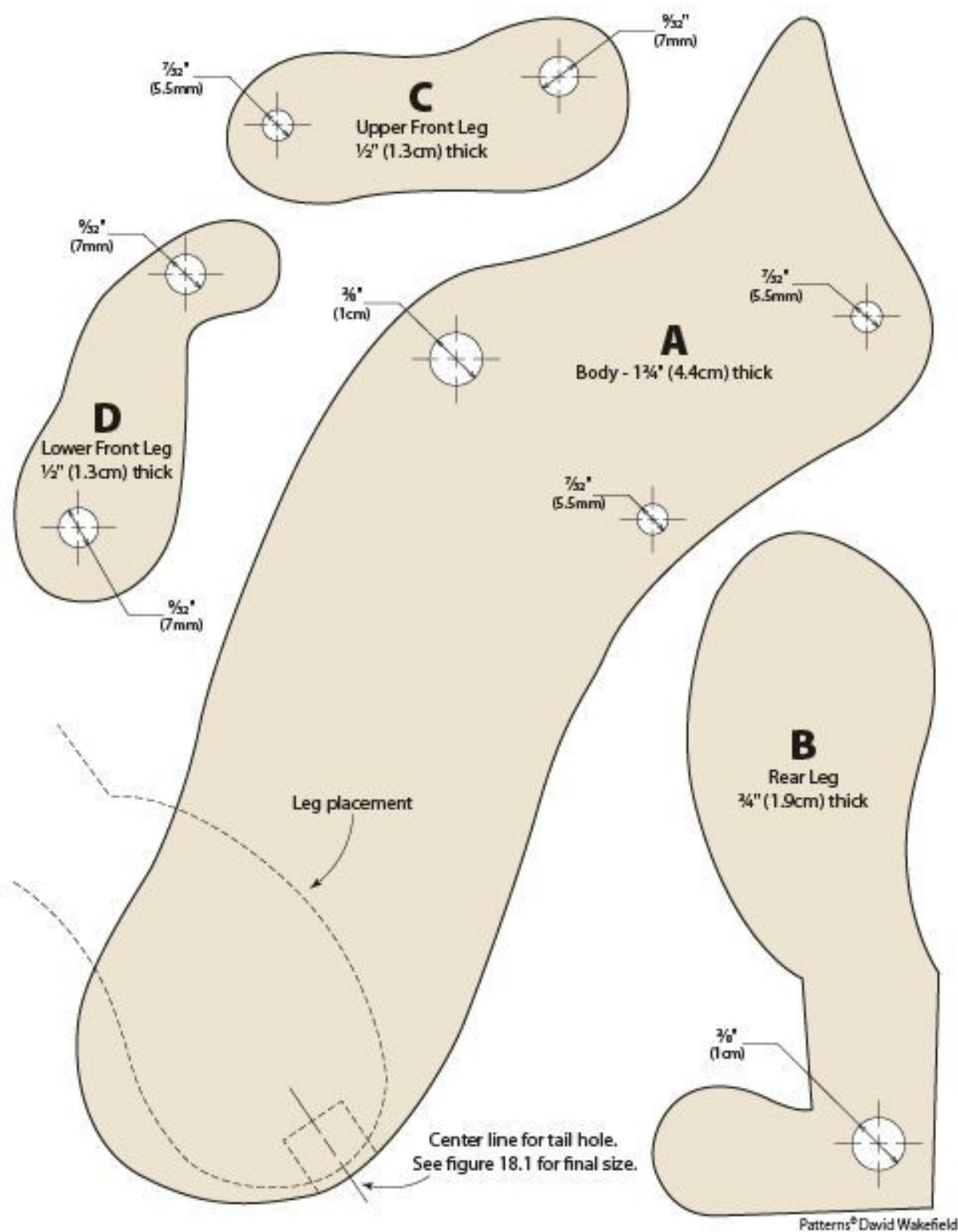
Patterns © David Wakefield

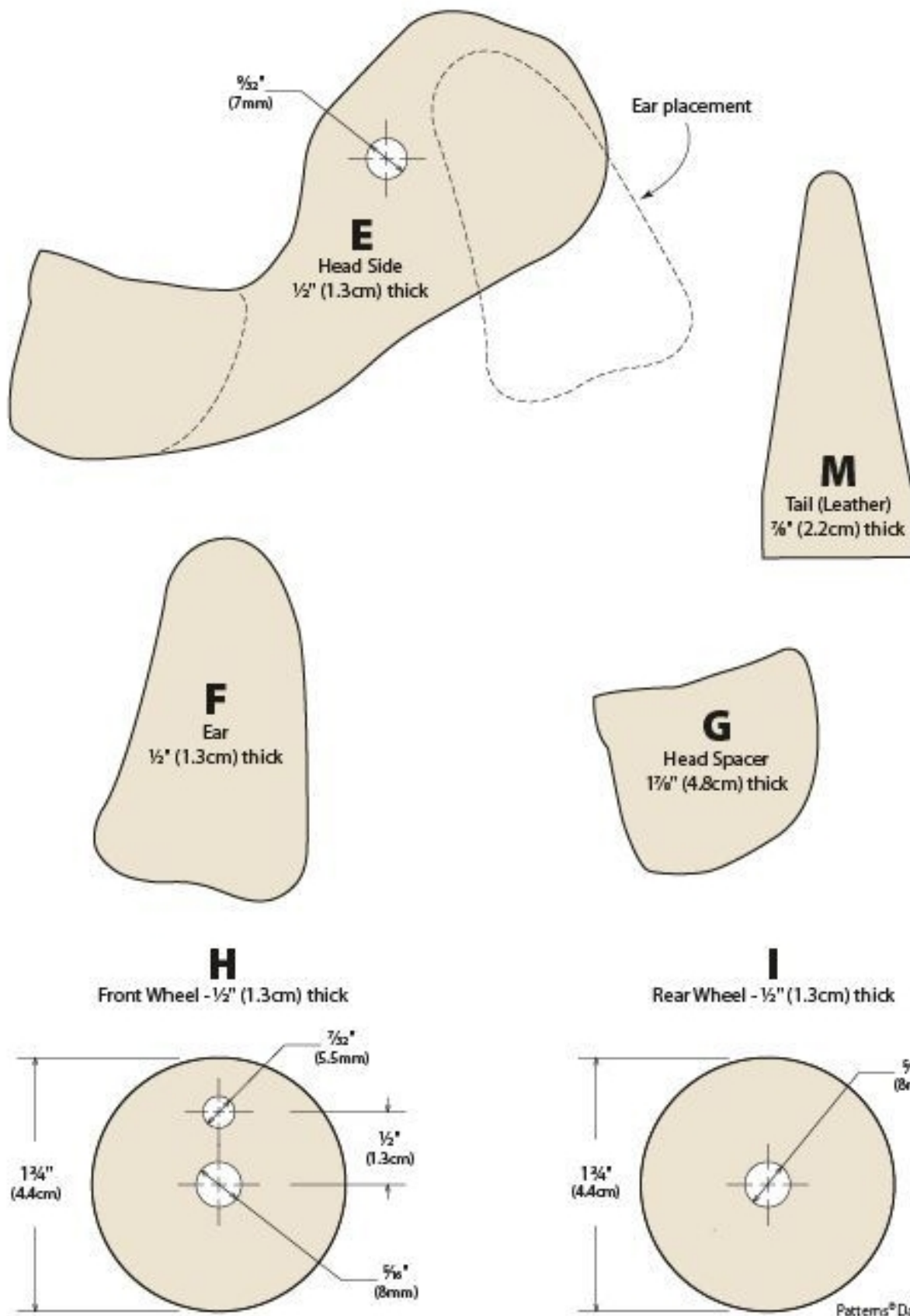


Patterns © David Wakefield

Materials

Part	Description	QTY	Thickness	Width or Diameter	Length
A	Body	1	1 3/4" (4.4cm)	4" (10.2cm)	9 1/2" (24.1cm)
B	Rear Legs	2	3/4" (1.9cm)	2" (5.1cm)	5" (12.7cm)
C	Upper Front Legs	2	1/2" (1.3cm)	1 1/4" (3.2cm)	3" (7.6cm)
D	Lower Front Legs	2	1/2" (1.3cm)	1 1/4" (3.2cm)	3" (7.6cm)
E	Head Sides	2	1/2" (1.3cm)	2" (5.1cm)	5" (12.7cm)
F	Ears	2	1/2" (1.3cm)	1 1/2" (3.8cm)	2 1/2" (6.4cm)
G	Head Spacer	1	1 7/8" (4.8cm)	1 3/8" (3.5cm)	1 5/8" (4.1cm)
H	Front Wheels	2	1/2" (1.3cm)	2 1/4" (5.7mm) diameter	—
I	Rear Wheels	2	1/2" (1.3cm)	2 1/4" (5.7mm) diameter	—
J	Front Axle	1	—	5/16" (8mm) diameter	2 5/8" (6.7cm)
K	Rear Axle	1	—	5/16" (8mm) diameter	4 1/2" (11.4cm)
L	Pegs	8	—	3/32" (5.5mm) diameter	1 1/8" (2.7cm)
M	Tail	1	1/8" (3mm)	1" (2.5cm)	2 3/4" (7cm)





19 Brawny Brontosaurus

Watch your garden; here comes the voluminous vegetarian. He has a brain at both ends of his body, so it's only fitting that his head and tail should gently sway up and down as he thuds along ponderously. The motion of his huge legs seems to propel him as he's pushed along.

I had an enormous version of this fellow in my first book and a miniature one in the second book. This one is right in the middle. I think it is the perfect size for kids or the coffee table.

The Head and Tail

Lay out the head and tail piece on a strong, clear piece of $\frac{3}{8}$ " (1.6cm) stock. Drill the $\frac{1}{4}$ " (6mm) eye hole and the $\frac{3}{8}$ " (1cm) pivot hole. As you cut out the shape on the band saw, pay attention to the details of the head silhouette, as these small curves help to give him character. Edge sand the silhouette with 80-grit and 120-grit sandpaper, again paying special attention to the detail in the head area (see Figure 19.1).

This piece is so long that it will have to be belt sanded with a handheld belt sander (on both sides) with 80-grit and then 120-grit sandpaper. Break all the edges by hand with 120-grit sandpaper.

The Legs

Lay out all eight leg pieces on $\frac{3}{8}$ " (1cm) stock. Drill all the holes and cut them out on the band saw. Notice that the knees and elbows have a smaller ($\frac{1}{2}$ " [5.5mm]) hole so the peg fits tightly, while the rest of the holes are $\frac{3}{2}$ " (7mm) to let the pegs pivot freely. Edge sand, flat sand, and hand sand them. You'll have to cut the pegs a bit shorter (see Toy Making Techniques, Figure 3.5) Assemble the legs in opposing sets and remove any glue that may have

been forced out the back of the holes. Flat sand the backs of these assemblies again with 120-grit sandpaper to remove any dried glue.

The Body

Lay out the sides (mirror images) on $\frac{3}{8}$ " (1cm) stock and cut them out on the band saw. Lay out the hole locations on one of the pieces and lay it on top of the other on the drill press. Drill both pieces



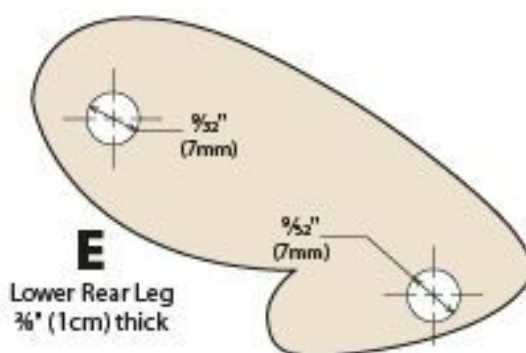
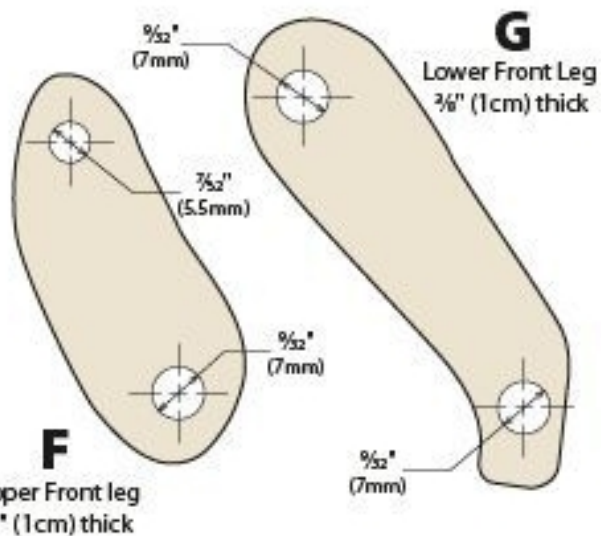
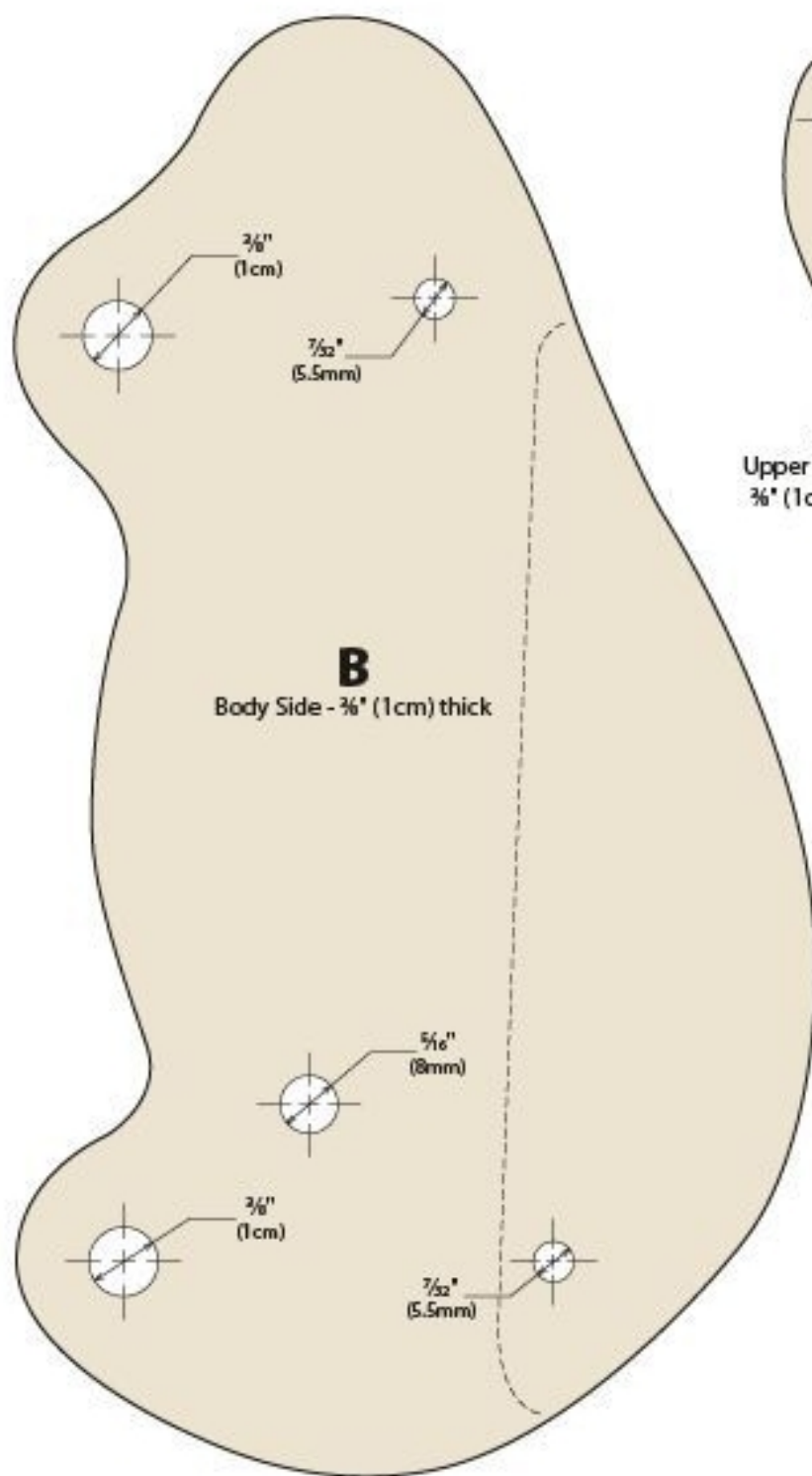
The cam wheel, hidden in the space between the body sides, causes the Brontosaurus's neck and tail to bob up and down as it turns.



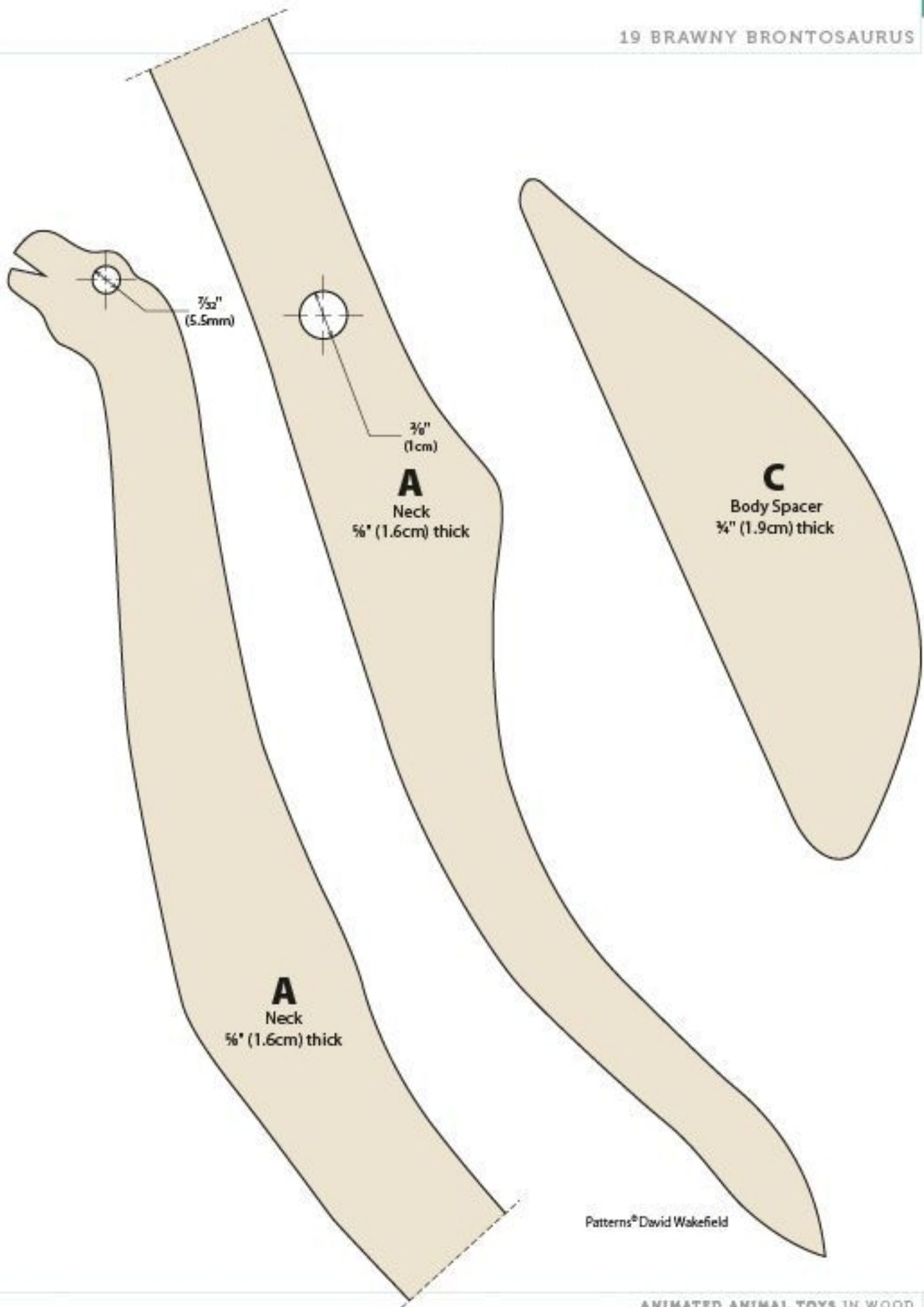
The front legs are pegged to opposing holes in the front wheels so the Brontosaurus appears to be lumbering forward.



The back legs are also pegged to the wheels, so all four feet are in motion when the toy is pushed.



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20 Solar Stegosaurus

As with most of the other dinosaurs in this book, I had a huge, complicated version of this beast in my second book *Making Dinosaur Toys in Wood* as well as a miniature one. This fellow is, I believe, just the right size for a child's hand or the corner of a desk in the office (for a bit of comic relief). The mechanism is fairly simple. The cam on the rear axle raises and lowers the spine arrangement as the legs do what they do...walk. The hardest part of this toy is getting the detail of the spine piece—and then sanding it.

The Body

Lay out the body sides on $\frac{3}{8}$ " (1cm) stock and cut out the two pieces carefully on the band saw. Lay one piece on top of the other and drill all the holes except the front axle, which will be drilled after the spacer is glued in place. Use a Forstner or brad point bit to avoid wandering, especially when punching through to the second piece. Edge sand the entire silhouette with 80-grit and 120-grit sandpaper, except the belly where the spacer will go. Flat sand both sides of both pieces and router the silhouettes, except, again, the belly area. Hand sand all the edges to remove burns and burrs. Lay out the spacer on $\frac{1}{2}$ " (1.3cm) stock and cut it out.

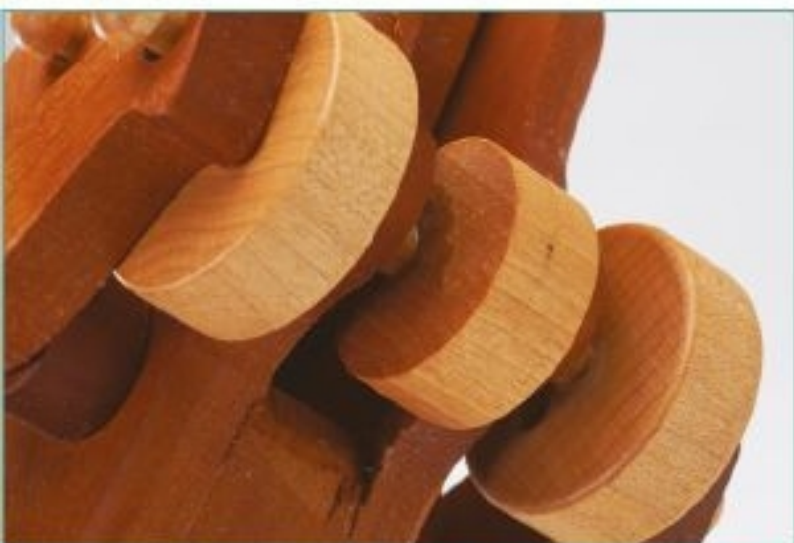
Put glue on both sides of the spacer, working it away from the edge to avoid excessive squeeze out. Put dowels through all the rear axle holes and the pivot holes to help with accurate assembly as you clamp it together. Insert $\frac{1}{4}$ " (6mm) dowels through the $\frac{5}{16}$ " (8mm) holes and $\frac{3}{16}$ " (8mm) dowels through the $\frac{3}{8}$ " (1cm) holes. If you stand the assembly upright, the dowels should rest on the bottom of the holes and go straight across (see Figure 20.1). Once the assembly is dry, you can edge sand the belly area and router that last bit of the silhouette. You'll also need to locate and drill the front axle hole.

The Spine

Lay out the spine piece on $\frac{1}{2}$ " (1.3cm) stock. Be sure to mark the center of all the $\frac{5}{16}$ " (8mm) holes at the base of the spines. These holes will help quite a bit when you are cutting out this piece. Drill all the holes and carefully cut it out. Use a $\frac{1}{4}$ " (3mm) blade on the band saw or use a scroll saw. You'll need a light touch to edge sand this piece. I start with 120-grit sandpaper and leave it at that. Flat sanding



All four feet are pegged to the wheels, giving the Stegosaurus lots of animation.



The cam wheel, mounted on the rear axle, lifts and lowers the spine as the axle turns.



The spine might take some extra time to cut out and shape, but the detail is well worth it.



Figure 20.1. Line the sides up as perfectly as possible with the help of dowels resting on the bottoms of the holes.

with just 120-grit sandpaper will do the job. A flat file will do a good job of putting a nice clean bevel on all the straight edges of the spines or plates. Hand sand with 120-grit sandpaper to break all the remaining edges.

The Legs

Lay out all the legs (two of each) on $\frac{3}{8}$ " (1cm) stock and drill the holes. Notice that the upper elbows and knees are $\frac{7}{32}$ " (5.5mm), not $\frac{1}{4}$ " (7mm), so the pegs will fit snugly when glued. These pieces are rather small. Unless you are totally confident cutting them out on the band saw, I recommend using a scroll saw or even a coping saw. Edge sand, flat sand, and break the edges with 120-grit sandpaper.

The Wheels and Cam

Drill the axle holes to $\frac{1}{8}$ " (8mm) and the peg holes to $\frac{7}{32}$ " (5.5mm) as in the patterns. Make the cam with a hole saw with a 1" (2.5cm) I.D. Plug the resulting axle hole and redrill an offset hole by

holding onto it with vise grips on the drill press table. If you make the axle hole slightly oversized ($\frac{21}{64}$ " [8.5mm]), it will be less likely to split during assembly.

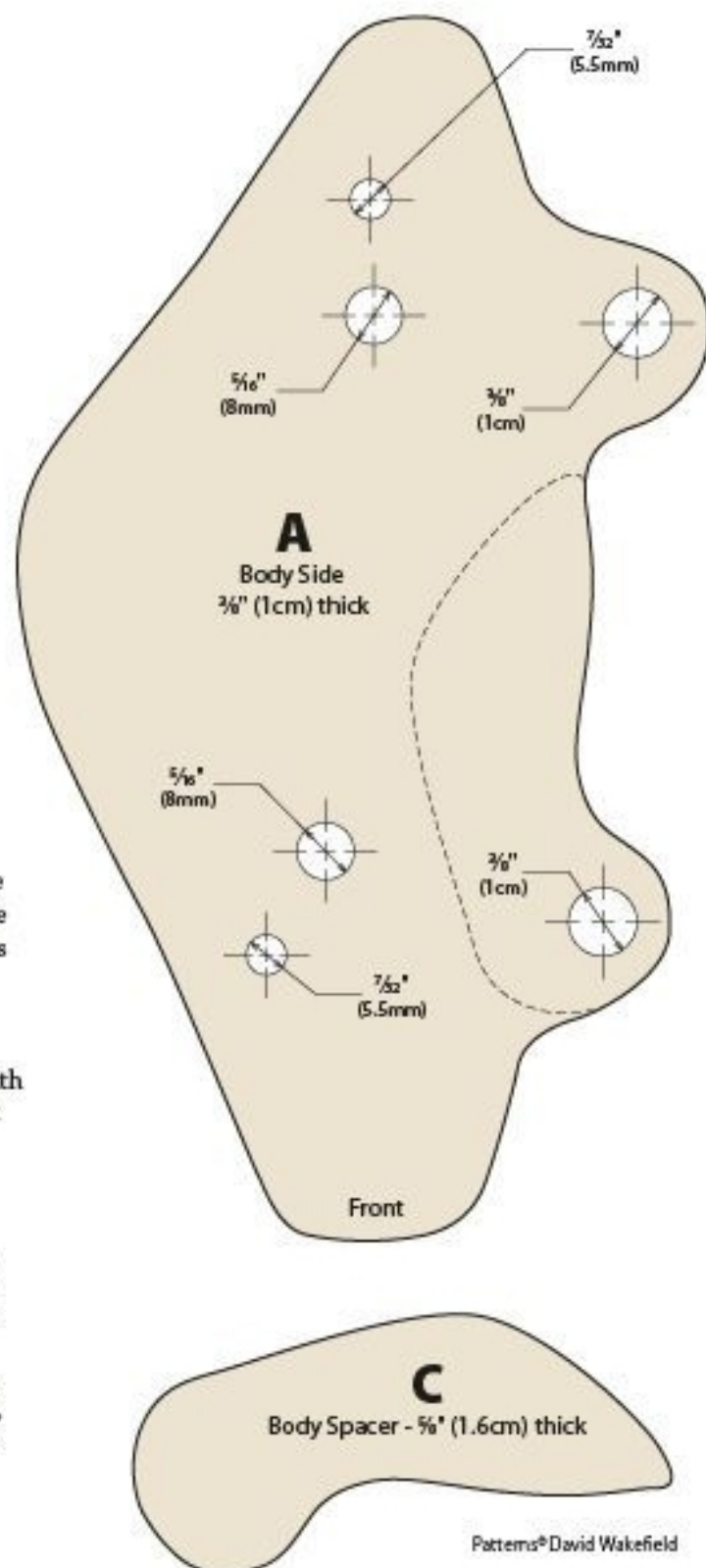
Assembly

Position the spine piece in place within the body assembly, lining up the holes. Cut the $\frac{1}{8}$ " (8mm) dowels a bit longer than the width of the assembly and round the ends with sandpaper. Tap the dowels into place until they just enter the second body side. Then, put a little glue inside the hole in the back and around the shaft of the protruding dowel. With the piece resting on wax paper, drive the dowels home. Wipe off excess glue. When the glue has dried, flat sand both sides lightly with 120-grit sandpaper to smooth off the ends of the dowel and remove any remaining glue.

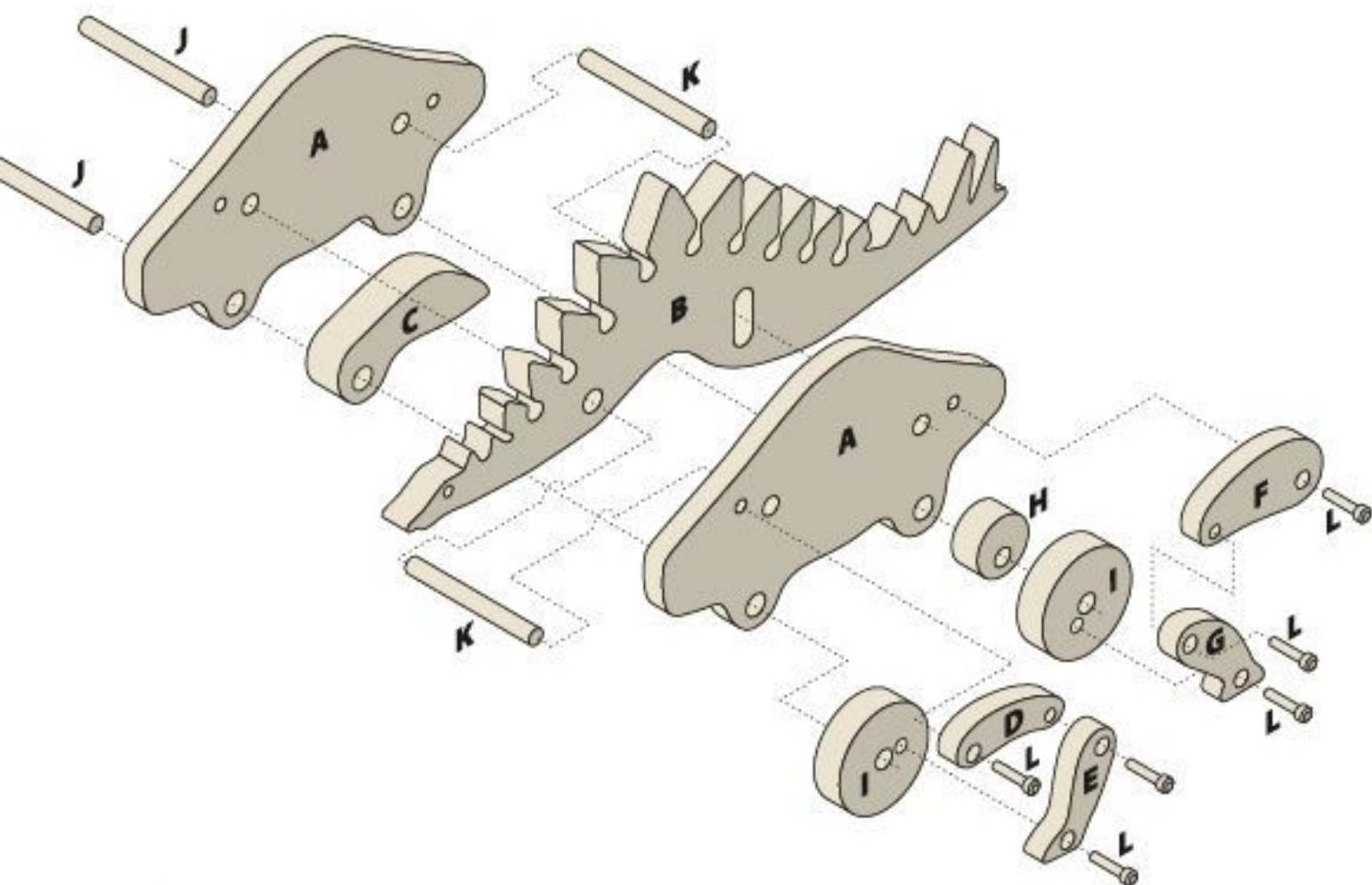
For the rear axle, glue one wheel to the axle and slip it through the cam before you go through the far side of the body. You may have to tap the axle through, resting the body on the edge of the workbench for support. Glue the second

wheel on, making sure the holes to attach the legs are diagonally opposed (one up, one down) by continuing to drive the dowel into the axle hole on the far side. Make sure the clearances are consistent; use a clearance gauge if necessary (see *Toy Making Techniques*, Figure 3.13). Repeat this process for the front axle (no cam to deal with here). Hold the whole toy on its back under the drill on the drill press to drill a $\frac{1}{16}$ " (2mm) hole through the cam and the axle. Glue and peg it with a toothpick. Break or cut off the excess toothpick and sand it flush.

You'll need to shorten all the pegs slightly to keep them from protruding out the back of the pieces (see *Toy Making Techniques*, Figure 3.5). Glue the legs together in opposing sets and sand any glue off the back of the assemblies. Peg and glue them first to the body and then to the wheels, using a clearance gauge (see *Toy Making Techniques*, Figure 3.13). Once all the glue is dry, you are ready to oil the Stegosaurus and add him to your menagerie.



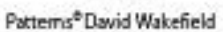
Patterns © David Wakefield



Materials

Part	Description	QTY	Thickness	Width or Diameter	Length
A	Body Sides	2	$\frac{3}{8}$ " (1cm)	$3\frac{3}{4}$ " (9.5cm)	7" (17.8cm)
B	Spine	1	$\frac{1}{2}$ " (1.3cm)	$3\frac{3}{4}$ " (9.5cm)	12" (30.5cm)
C	Body Spacer	1	$\frac{5}{8}$ " (1.6cm)	$1\frac{1}{2}$ " (3.8cm)	3" (7.6cm)
D	Upper Front Legs	2	$\frac{3}{8}$ " (1cm)	1" (2.5cm)	$2\frac{1}{4}$ " (5.7cm)
E	Lower Front Legs	2	$\frac{3}{8}$ " (1cm)	1" (2.5cm)	$2\frac{1}{4}$ " (5.7cm)
F	Upper Rear Legs	2	$\frac{3}{8}$ " (1cm)	$1\frac{1}{4}$ " (3.2cm)	$2\frac{1}{2}$ " (6.4cm)
G	Lower Rear Legs	2	$\frac{3}{8}$ " (1cm)	1" (2.5cm)	$2\frac{1}{4}$ " (5.7cm)
H	Cam Wheel	1	$\frac{1}{2}$ " (1.3cm)	1" (2.5cm)	—
I	Wheels	4	$\frac{1}{2}$ " (1.3cm)	$1\frac{3}{4}$ " (4.4cm)	—
J	Pivot Dowels	2	—	$\frac{5}{16}$ " (8mm) diameter	$1\frac{3}{8}$ " (3.5cm)
K	Axles	2	—	$\frac{5}{16}$ " (8mm) diameter	$2\frac{1}{2}$ " (6.4cm)
L	Pegs	12	—	$\frac{3}{32}$ " (5.5mm) diameter	$1\frac{1}{8}$ " (2.7cm)

Patterns © David Wakefield



21 Tyrannical Tyrannosaurus

The Tyrannosaurus is perhaps the most familiar of all dinosaurs.

He is well known as a ferocious predator, but did you know that he is thought to have been a scavenger, drawn to the smell of carcasses?

How Does It Work?

As you push this fellow along, holding on to his tail, his mouth opens and closes threateningly by means of a cam and a drive dowel, while the offset wheels and attached legs give him an ominous swaying gait.

The only difficulty in making the Tyrannosaurus is the small size of some of the pieces.

I have resized this fellow. In my first book, he was huge. In my second book I made a miniature version, but this guy is in between and, I think, just the right size for a child to play with (or to put on your desk).

The Body

Lay out the body pattern so the bottom of the slot is parallel with the jointed edge of a board (see Figure 21.1). This will make it safe and easy to cut out the slot for the cam. Drill the axle hole before cutting the slot. You may as well drill the holes for the pegs at this point (head and leg attachment).

I use a set of dado blades to cut out the slot. I set the width of the dado to $\frac{5}{8}$ " (1.6cm) (the width of the slot) and I make the cut in two passes, the first one at half the height. I rest the piece on the nice long jointed edge of the board to make the cut safely.

When you cut out the silhouette, cut straight across the top of the teeth instead of cutting them out. This will make it easier to drill the hole for the $\frac{3}{16}$ " (8mm) drive dowel.

I have a simple jig for drilling that consists of two boards glued together at right angles. This holds the body in a vertical position while the block under the axle hole supports the body at the correct angle. Use a square to be sure of the angle and clamp it in place so it doesn't move (see Figure 21.2). Use a Forstner bit for this hole so it won't wander. Then, drill the $\frac{5}{8}$ " (1cm) drive hole.

You can cut out the teeth now. Then, transfer the top view of the tail onto the body piece with a piece of paper that will lie flat on the contoured tail. Standing it up and holding it firmly, cut out the sculpted sides of the tail.

Flat sand both sides of the body and edge sand the entire silhouette. Router the outline, except



The drive dowel, inserted through a hole in the Tyrannosaurus's body, opens and closes the mouth in a roar.



The cam wheel, mounted on the front axle, lifts and lowers the drive dowel.



The shaping of the neck helps this toy maintain the proper proportions.



Figure 21.1. Laying out the pattern with the top of the slot parallel to the jointed edge of the board makes it easy to cut out the slot on the table saw with a dado set.

the head and the tail. Then clamp the body upside down in a vise and round over the edges of the tail with a four-in-hand rasp. You may as well hand sand the tail while it's in the vise.

Now, with the body face down, make two marks on top of the head to indicate where to cut away the sides of the head. Set the rip fence on the band saw, first to cut one side and then to cut the other, to a distance of $1\frac{3}{4}$ " (4.4cm) from the top of the head. Make sure you end up with a little more than $\frac{3}{4}$ " (1.9cm) thickness, so edge sanding will take it down to $\frac{3}{4}$ " (1.9cm) thick. Then, with the rip fence removed, continue these cuts, angling out to the edge of the piece. The angle of the cut is not as critical as making both cuts the same.

Now, with the face still downward, edge sand these areas. Hand sand the whole body to remove

any roughness or crossgrain scratches and smooth all the routed and unrouted edges. Use a flat file to break the edges of each side of each of the teeth.

The Head

To make the head piece, lay out both of the side pieces on $\frac{3}{8}$ " (1cm) stock and the spacer on $\frac{7}{8}$ " (2.2cm) stock. Cut out the sides (including the teeth) and flat sand them. Lay the pieces on top of each other and drill the eyeholes to ensure they will line up properly during assembly. Edge sand the silhouette of the spacer, except the top where the sides will meet the spacer.

Use the jig to accurately glue the head sides to the spacer (see Toy Making Techniques, Figures, 3.14, 3.15, and 3.16). Take the assembly off the jig to apply a second clamp, being careful that

the assembly does not shift. After the glue has thoroughly set up, edge sand the silhouette except the teeth. They can be smoothed with a flat file.

Lay out the top view of the head. With teeth resting on the band saw table, cut away the tapered sides. Flat sand these sawn areas, and then rock the piece on the belt sander to flat sand the rest of the side and smooth the transition between the two surfaces. Round over the edges with sandpaper. A file will help to break the sharp edges on the teeth and give them a clean beveled edge.

The Legs and Arms

Lay out, drill, and cut out the legs and arms. Take note of the different hole sizes; some must be snug while others must allow movement.

Cut out the legs and arms on the band saw if you are totally confident in your skill. If you are the least bit nervous, use a scroll saw or a coping saw. Again, the sanding can be done on the machines or by hand, depending on your experience and confidence.

The Wheels and Cam

Glue short sections of dowel to plug the axle holes on the wheels. Redrill the axle holes slightly off center, as in the patterns (see *Toy Making Techniques*, Figures 3.9 and 3.10). Then drill the holes to attach the feet to the wheels. (Note the wheel patterns. The hole is on the opposite side of the wheel from the newly drilled axle hole.)

To make the cam, use a hole saw to cut out a 1" (2.5cm) wheel. Plug the hole and drill a new one as in the pattern, using vise grips to keep the cam from spinning as you drill. If you drill the hole slightly oversized ($\frac{3}{16}$ " [8.5mm]) it will be less likely to split during assembly.

Assembly and Finishing

Cut the axle to length, glue it to one of the wheels and slip the cam on the axle as you pass it through the body. Glue the other wheel on, making sure that one peg hole is up and the other down.



Figure 21.2. Clamping the body to a simple jig with a block under the axle hole will ensure accurate drilling of the long $\frac{3}{8}$ " (1cm) hole for the drive dowel.

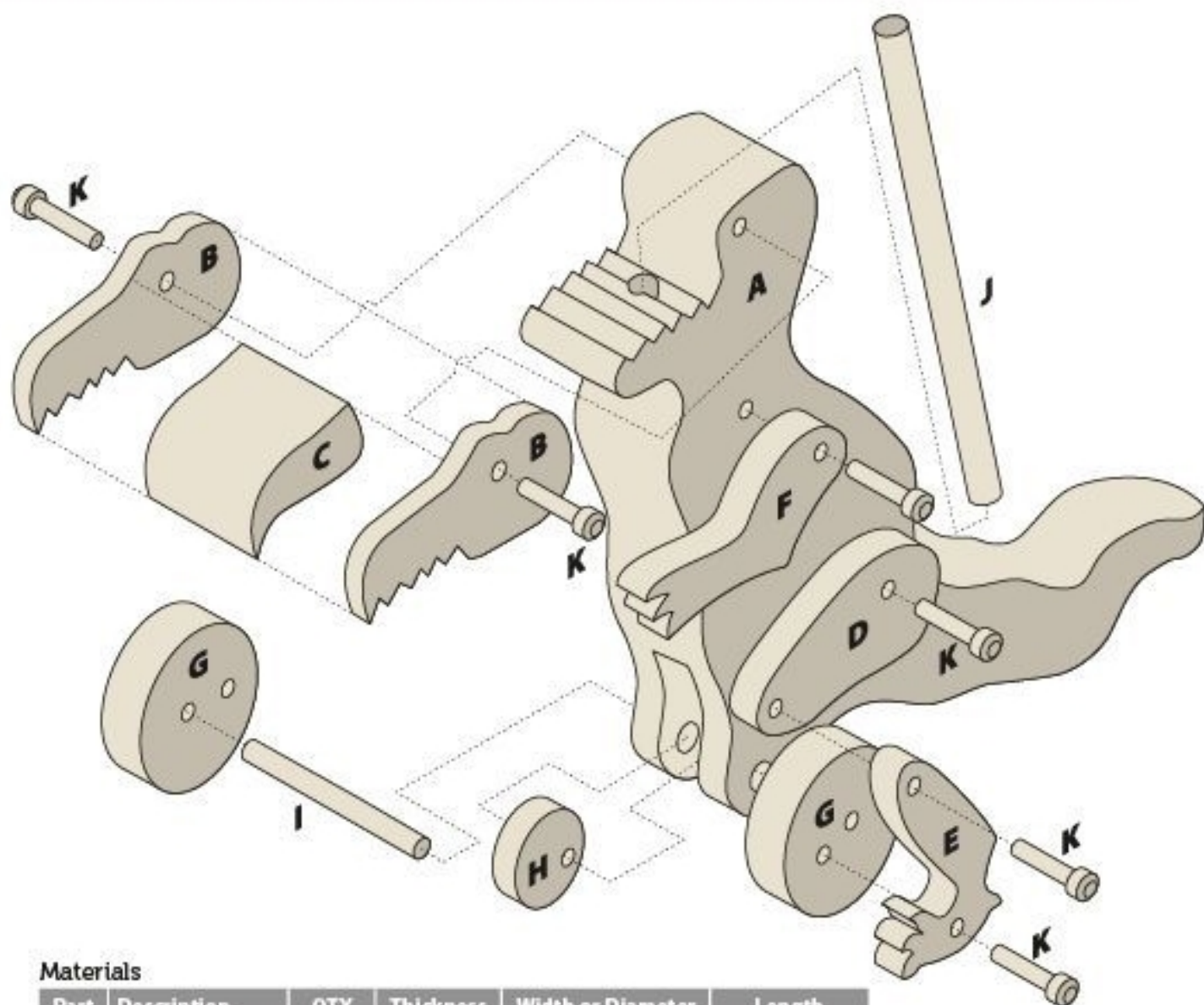


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When the glue is dry, sand the ends of the axle on the sander or grinder or by hand.

Drill a small hole through the cam and the axle and pin it in place with a toothpick and some glue. Cut off the excess and sand it smooth.

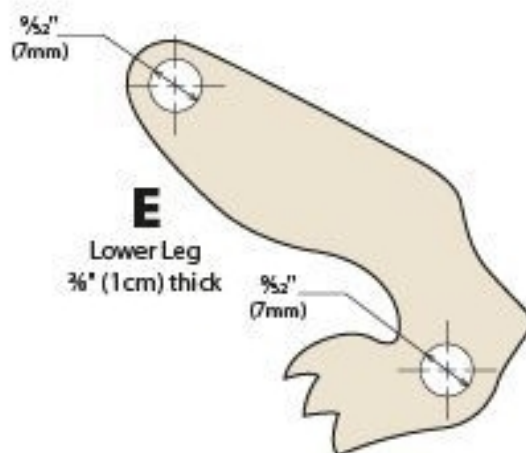
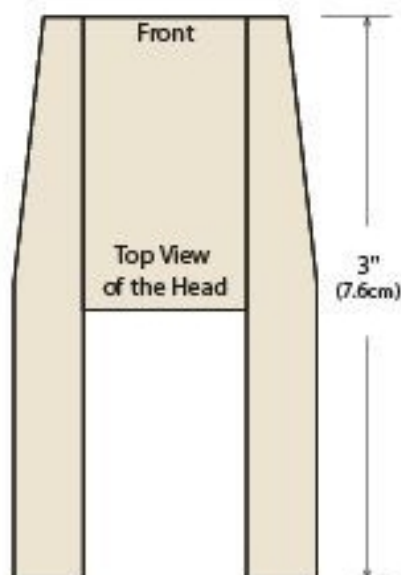
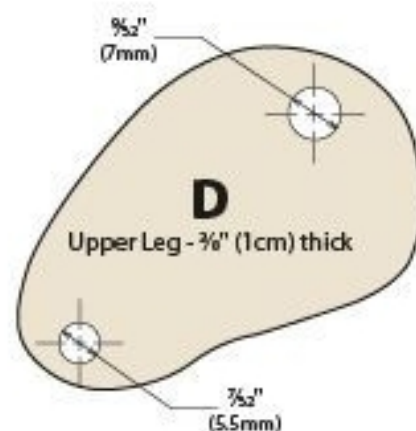
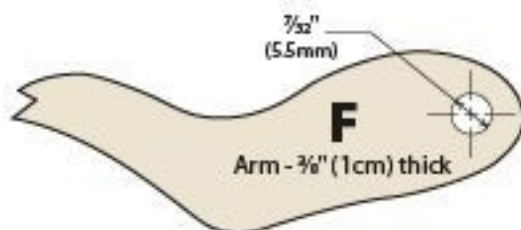
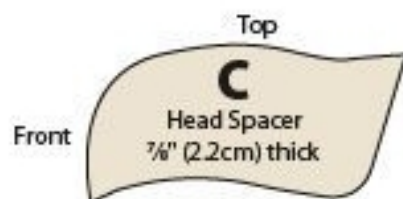
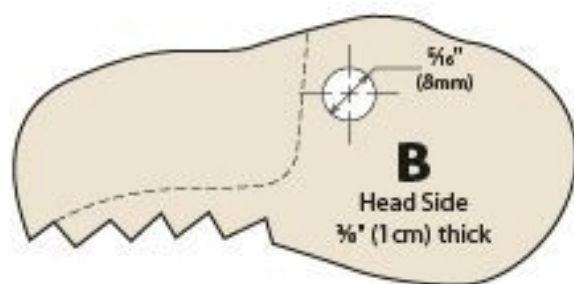
You may have to cut the pegs a bit shorter to assemble the legs and fasten them to the wheels (see Toy Making Techniques, Figure 3.5). Glue and peg the leg assemblies together in opposing sets using the clearance gauge (see Toy Making Techniques, Figure 3.13). Then glue and peg the leg assemblies to the body and the wheels. Glue and peg the arms tightly in place. Insert the drive dowel (with both ends slightly rounded over) and peg the head lightly in place without glue. You'll probably have to cut them a bit shorter. Adjust the length of the drive dowel, if necessary, and then glue and peg the head in place, leaving equal clearance on either side for smooth movement. After all the glue has set up, oil him up and there you have him. It's the King of the Carnivores in a somewhat less threatening size!



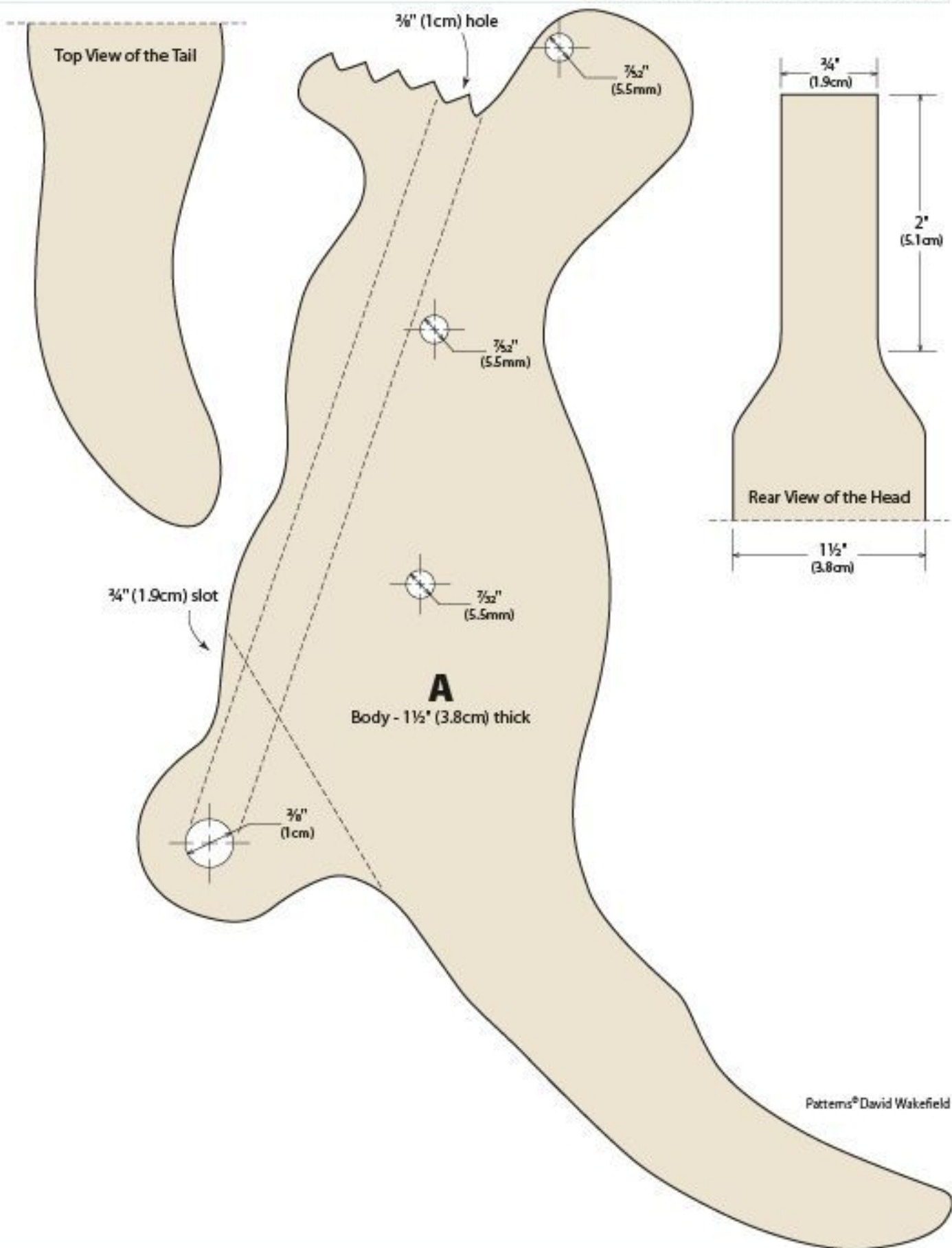
Patterns © David Wakefield

Materials

Part	Description	QTY	Thickness	Width or Diameter	Length
A	Body	1	1½" (3.8cm)	6" (15.2cm)	10¼" (26cm)
B	Head Sides	2	¾" (1cm)	1½" (3.8cm)	3½" (7.9cm)
C	Head Spacer	1	¾" (2.2cm)	1" (2.5cm)	2" (5.1cm)
D	Upper Legs	2	¾" (1cm)	1½" (3.8cm)	2½" (6.4cm)
E	Lower Legs	2	¾" (1cm)	1½" (4.1cm)	2¾" (7cm)
F	Arms	2	¾" (1cm)	1" (2.5cm)	3" (7.6cm)
G	Wheels	2	½" (1.3cm)	1¾" (4.4cm) diameter	—
H	Cam Wheel	1	½" (1.3cm)	1" (2.5cm) diameter	—
I	Axle	1	—	⅝" (8mm) diameter	2⅝" (6.7cm)
J	Drive Dowel	1	—	⅝" (8mm) diameter	6" (15.2cm) (approximately)
K	Pegs	10	—	⅜" (5.5mm) diameter	1⅞" (2.7cm)



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22 Dramatic Dimetrodon

The Dimetrodon was one of the first dinosaurs, arriving about 100 million years before our friend the Tyrannosaurus. This one sports a bobbing sail, as well as an opening mouth, both of which are accomplished by the cam on the rear axle. This guy is quite challenging because of the detail of the three piece sail, but personally, I think he is a real classic.

The Body

Lay out the sides on $\frac{3}{8}$ " (1cm) stock. Lay one side over the other and carefully drill the holes (except the eyehole and the front axle hole, which will be drilled after the spacers are glued in place) with a Forstner or brad point bit to avoid wandering. Pay attention that the second piece doesn't shift as you break through. It is critical that these pieces are identical for accurate assembly and smooth functioning of the sail/mouth piece. Edge sand all the edges that will not have a spacer coming to the edge. That means the ridges down the back where the sail comes out, the chest, and both axle hole areas. Flat sand both sides of both pieces with 80-grit and 120-grit sandpaper.

Lay out the three spacers on $\frac{3}{8}$ " (2.2cm) stock and cut them out. Edge sand the transitional areas on these edges: the front of the tail spacer; the back and underside of the head spacer; and the front, back, and top of the belly spacer. You will not be able to sand them after assembly.

Now, put glue on both sides of both spacers, working it back from the edges to avoid excessive squeeze out. Place them very carefully in position on the inside of one of the side pieces. Place the second side piece on top and hand squeeze the assembly to get everything settled before you apply the clamps. Use at least two clamps on each spacer area and watch for shifting. When the assembly has set up, lay out and drill the eyehole and the front axle hole and carefully cut out the teeth.

Then, edge sand the spacer edges with 80-grit and 120-grit sandpaper, going for a smooth transition from spacer to no spacer. A flat file will work better on the teeth than the edge sander. Use a router to create the entire silhouette except for the teeth. Use a file to put a nice, clean bevel on each side of each tooth.

Lay out the top view of the head and the tail and rest the body firmly on the axle areas as you cut away the head and tail sides. Keep the body upright and edge sand the head and tail sides with 80-grit and then 120-grit sandpaper. Put the piece in a vise, tail upward, and file the whole tail with



All four of the Dimetrodon's legs rotate on the pegs attached to the body.



The cam wheel, mounted on the rear axle, causes the sail to bob up and down and the mouth to open and close.



Using contrasting colors of wood for the sail pieces produces a beautiful visual effect.



Figure 22.1. Hold each rib firmly as you lightly sand the edges.

a four-in-hand rasp. Hand sand with 80-grit and 120-grit sandpaper. Repeat the rasping, filing, and sanding process for the head.

The Sail and Lower Jaw

The center of the sail is pretty straight forward. Just lay it out with the grain running from right to left. A contrasting color of wood looks good for this part. We will drill the holes after assembly. Cut out the silhouette as accurately as possible. Flat sand both sides with 80-grit and 120-grit sandpaper.

Flat sand the outer rib pieces on both sides with 80-grit and 120-grit sandpaper before laying them out (you won't be able to sand them later). Lay them out with the grain running vertically. This will make the ribs of the fin as strong as possible. Carefully drill the holes at the base of each rib and cut out the bottom edge as close to the pattern as you can; they should match up with the center piece. Cut out the top edge, leaving about $\frac{1}{8}$ " (3mm) extra.

Now, carefully cut down the side of each rib to the hole at the bottom. I used a $\frac{1}{8}$ " (3mm) blade on the band saw; alternately, you can use a scroll saw.

Take your time on this because it will be impossible to edge sand or correct these cuts after they are made. After you've made all these cuts, carefully cut the tips to the proper length and angle. Hand sand the edges of the ribs on the back side (toward the center piece) to remove any burrs from sawing (see Figure 22.1). The edges facing outward can be sanded after assembly.

Put glue on the back of one of the outer rib pieces and just a little down the length of each rib. Run the end of your finger down each edge to push the glue back from the edges; you don't want any to squeeze out when you clamp the assembly together. Place the piece carefully onto the center sail piece and flip the two pieces over onto a small board that you can use to spread out the pressure over the entire piece as you clamp the assembly together. When the glue has dried, repeat this process for the other side.

At this point you can lay out the $\frac{3}{8}$ " (1cm) pivot hole in the front of the sail and the $\frac{1}{2}$ " (1.3cm) holes for the slot in the back and drill them. You'll need to use a Forstner bit to enable you to drill the overlapping holes for the rear pivot slot. Use a rat tail file or a riffler file to smooth out the remaining material on the sides of the rear pivot slot.

You can use the edge sander for the bottom edge of the assembly, but use a drum sander (or a dowel wrapped in sandpaper; see *Toy Making Techniques*, Figure 3.11) to sand the edge of the rest of the sail piece. After a little hand sanding, you can move on to the lower jaw piece.

Lay out the lower jaw piece on $\frac{3}{4}$ " (1.9cm) stock and cut it out. Edge sand the silhouette, except the teeth, with 80-grit and 120-grit sandpaper. File the teeth with a flat file and then use the flat file (with the piece in a vise) to put a clean bevel on each of the teeth. Make sure the joining surfaces of the jaw piece and the sail are both flat and fit together smoothly.

Gluing these pieces together presents a bit of a challenge because of the odd shape of the sail. I cut out a $\frac{3}{4}$ " (1.9cm)-thick piece in the shape of the upper silhouette of the sail and clamped the pieces against it (see Figure 22.2).

The Legs

Lay out two of each leg on $\frac{3}{8}$ " (1cm) stock. Notice that the knee and elbow holes are smaller ($\frac{7}{32}$ " [5.5mm]) so the pegs fit tightly while the other holes let the pegs pivot freely. Cut out the legs. Edge sand and flat sand them all with 120-grit sandpaper. Break all the edges with 120-grit sandpaper by hand. You'll need to shorten the pegs (see Toy Making Techniques, Figure 3.5). Glue the legs together in opposing sets using the clearance gauge (see Toy Making Techniques, Figure 3.13). Flat sand the back of each set after the glue has dried to remove any glue.

The Wheels and Cam

The cam is made with a 1" (2.5cm) i.d. hole saw. Plug the original axle hole and drill the new offset axle hole as in the pattern, using vise grips to hold it firmly on the drill press as you drill. If you drill it slightly oversized ($\frac{21}{64}$ " [8.5mm]), it will be less likely to split during assembly. If you use the edge

sander to clean up the tread surface, be careful not to alter the circular shape.

Drill the peg holes in all four wheels as in the patterns, using a board clamped to the drill press table for a stop and to set the distance from the edge of the wheel (see Toy Making Techniques, Figure 3.9).

Assembly

Slip the sail assembly into place, lining up the holes with those in the body. Cut the $\frac{3}{16}$ " (8mm) dowels to length (a bit long) and round the ends slightly with sandpaper. Tap them through the body until they just enter the hole in the second side. Then, put a little glue around the protruding dowels and into the hole on the back side. Put the piece on wax paper and drive the dowels home. Wipe off any excess glue, and, after the glue has set up, flat sand both sides lightly with 120-grit sandpaper to remove any remaining dried glue.

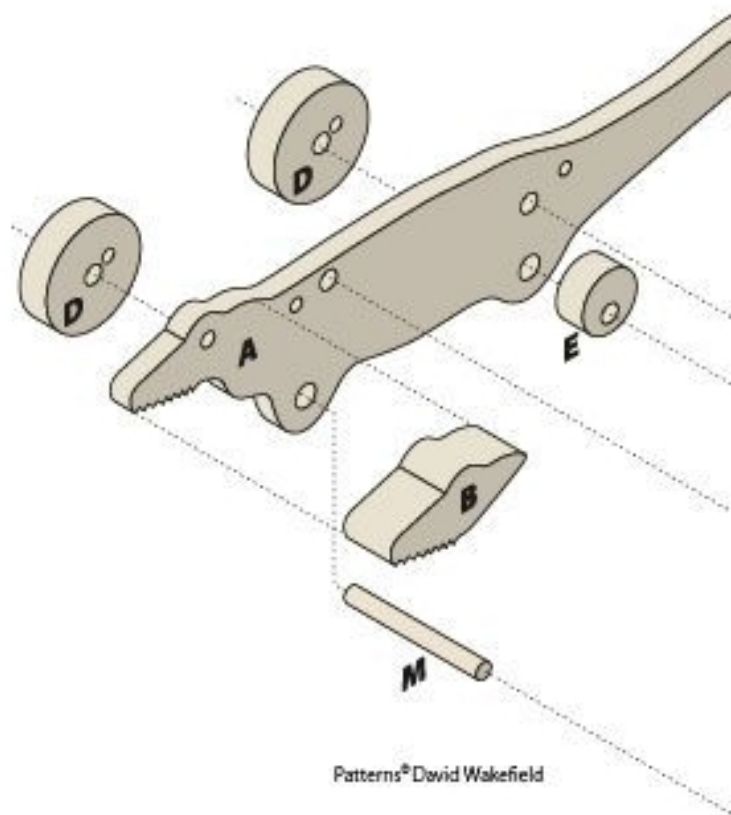


Figure 22.2. I used a piece cut out like the silhouette of the top of the sail to clamp the pieces against when attaching the lower jaw.

Cut the axles to length and hand sand the ends to round them slightly. Put glue on the inside of one of the wheels, and, with the wheel sitting on wax paper, drive the dowel home. Wipe off the excess glue, slide it through the front axle holes, and drive the other wheel on (with glue lining the hole). Be sure the peg holes are diagonally opposed: one up, one down. Repeat this process for the back axle, positioning the cam between the body sides as you tap the dowel through.

Hold the toy upside down, with most of the cam below the axle, and drill a $\frac{1}{16}$ " (2mm) hole through the cam and the axle with a hand drill. Glue a toothpick into the hole and break off the end. Sand it flush to the surface. Cut eight pegs to length using a simple jig on the band saw table (see Toy Making Techniques, Figure 3.5). Now peg the legs to the body and the wheels using glue in the holes and a clearance gauge (see Toy Making Techniques, Figure 3.13).

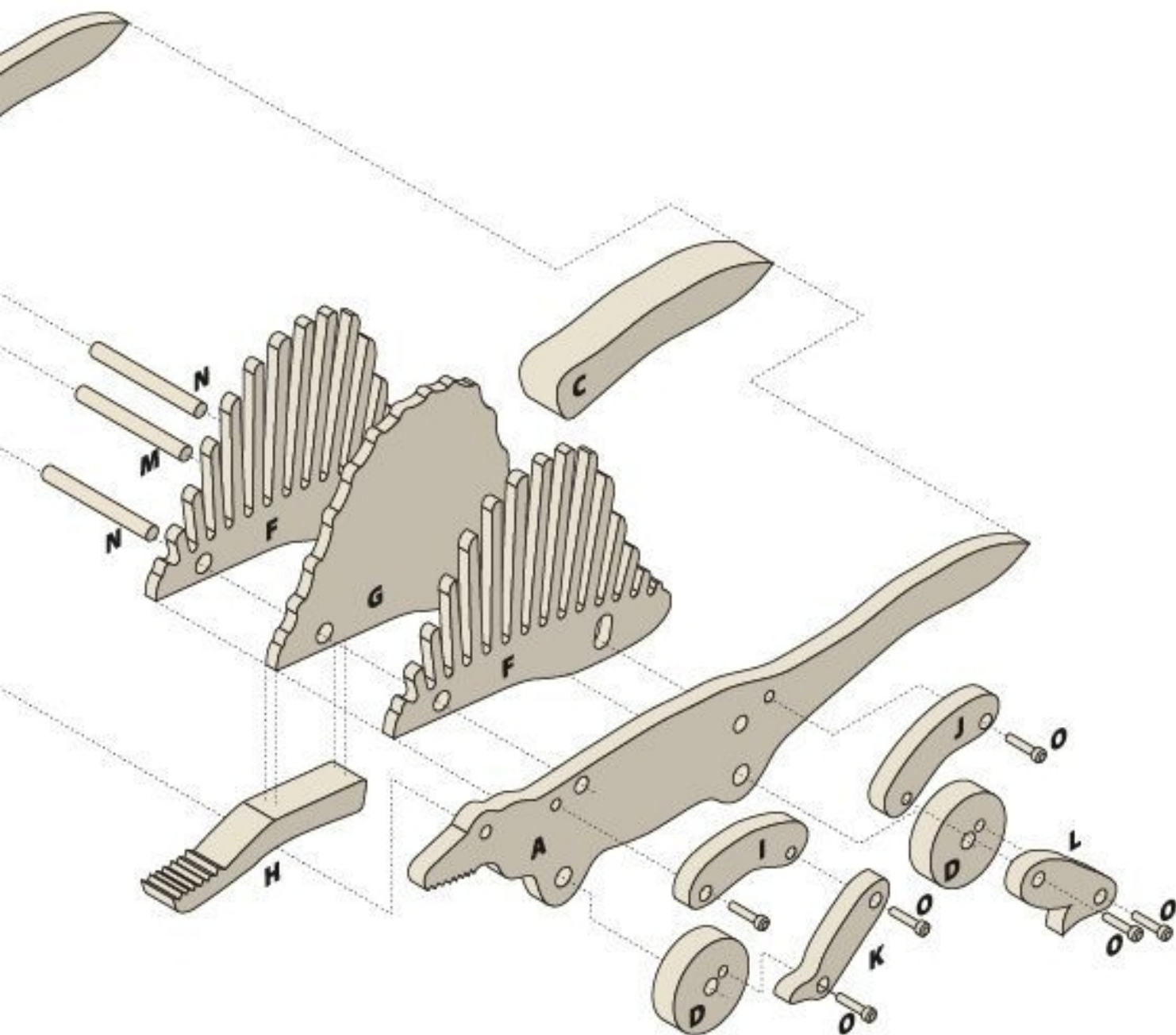
When all the glue has thoroughly set up, you can oil this guy and add him to your collection.



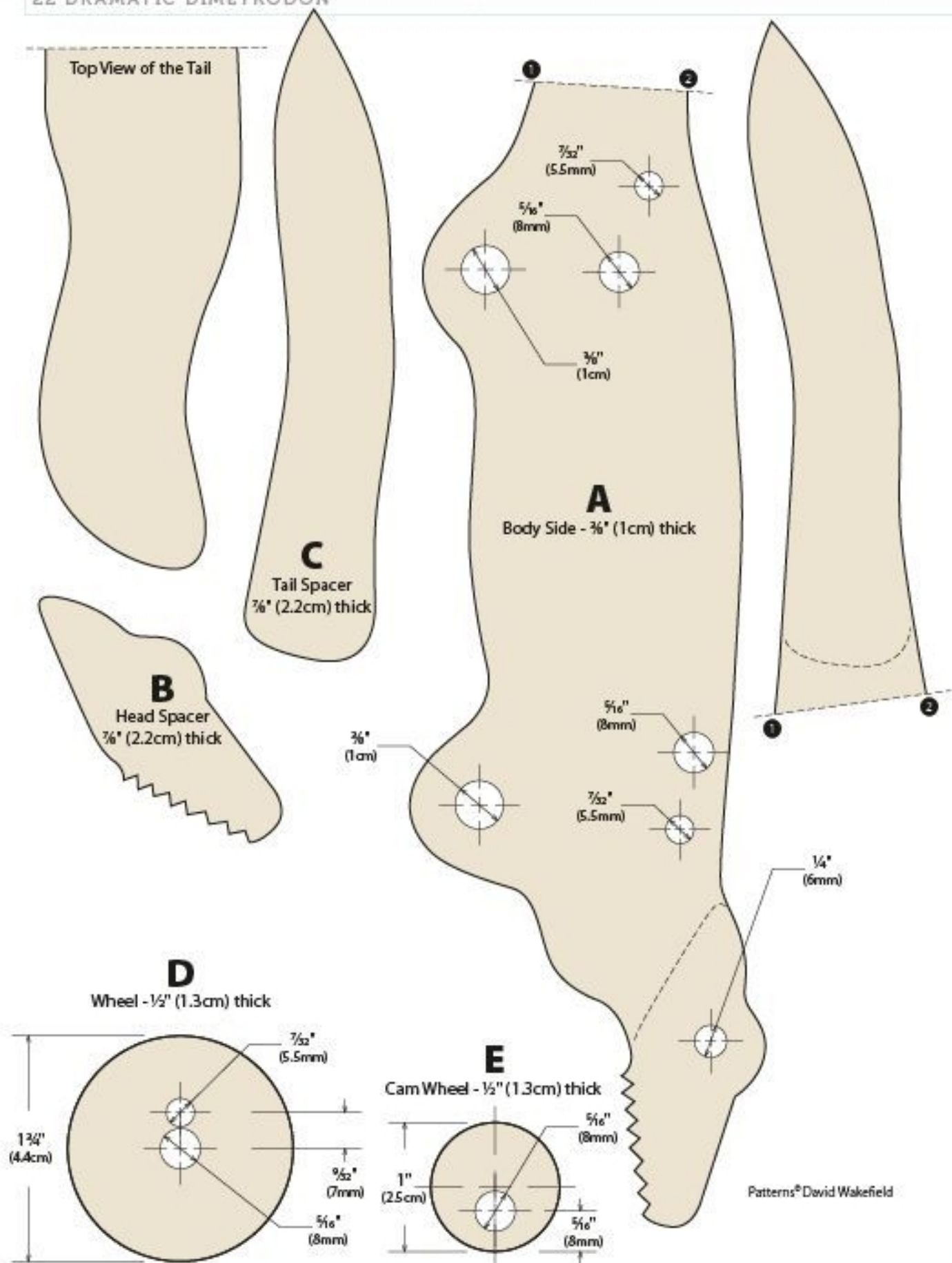
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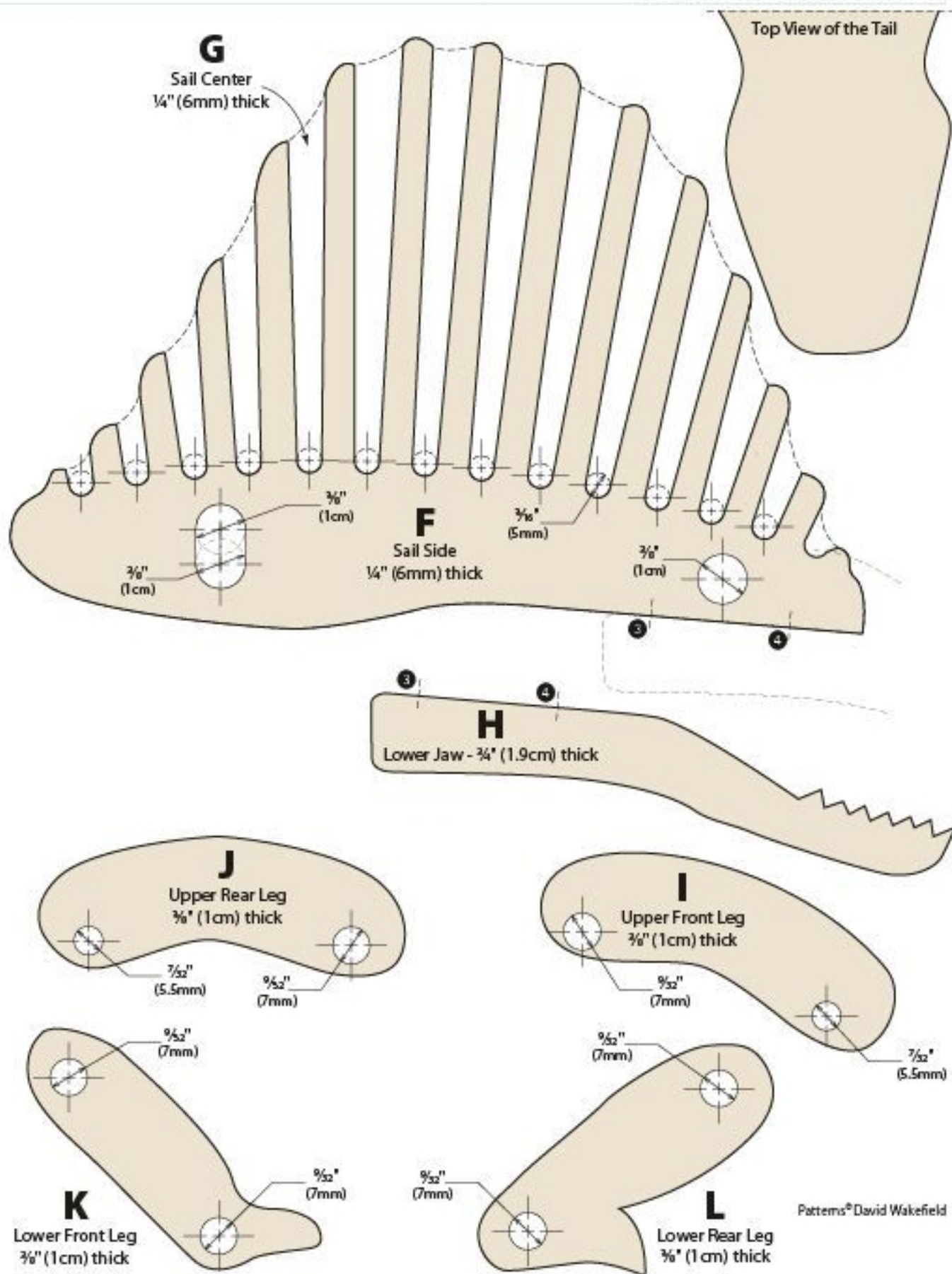
Materials

Part	Description	QTY	Thickness	Width or Diameter	Length
A	Body Sides	2	$\frac{3}{8}$ " (1cm)	3" (7.6cm)	14 $\frac{1}{4}$ " (36.2cm)
B	Head Spacer	1	$\frac{7}{8}$ " (2.2cm)	1 $\frac{1}{4}$ " (3.2cm)	2 $\frac{3}{4}$ " (7cm)
C	Tail Spacer	1	$\frac{7}{8}$ " (2.2cm)	1 $\frac{1}{4}$ " (3.2cm)	5" (12.7cm)
D	Wheels	4	$\frac{1}{2}$ " (1.3cm)	1 $\frac{3}{4}$ " (4.4cm) diameter	—
E	Cam Wheel	1	$\frac{1}{2}$ " (1.3cm)	1" (2.5cm) diameter	—
F	Sail Sides	2	$\frac{1}{4}$ " (6mm)	6 $\frac{3}{4}$ " (17.1cm)	4 $\frac{1}{2}$ " (11.4cm)
G	Sail Center	1	$\frac{1}{4}$ " (6mm)	4 $\frac{1}{2}$ " (11.4cm)	6 $\frac{3}{4}$ " (17.1cm)
H	Lower Jaw	1	$\frac{3}{4}$ " (1.9cm)	1" (2.5cm)	4 $\frac{5}{8}$ " (11.7cm)
I	Upper Front Legs	2	$\frac{3}{8}$ " (1cm)	1 $\frac{1}{4}$ " (3.2cm)	3" (7.6cm)
J	Upper Rear Legs	2	$\frac{3}{8}$ " (1cm)	1 $\frac{1}{4}$ " (3.2cm)	3" (7.6cm)
K	Lower Front Legs	2	$\frac{3}{8}$ " (1cm)	1 $\frac{1}{2}$ " (3.8cm)	2 $\frac{3}{4}$ " (7cm)
L	Lower Rear Legs	2	$\frac{3}{8}$ " (1cm)	1" (2.5cm)	3" (7.6cm)
M	Wheel Axles	2	—	$\frac{5}{16}$ " (8mm) diameter	2 $\frac{3}{4}$ " (7cm)
N	Sail Axles	2	—	$\frac{5}{16}$ " (8mm) diameter	1 $\frac{5}{8}$ " (4.1cm)
O	Pegs	12	—	$\frac{7}{32}$ " (5.5mm) diameter	1 $\frac{1}{8}$ " (2.7cm)



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23 “Nessie” the Plesiosaurus

The Plesiosaurus was a huge sea creature. One fossil was found in Australia with a head 8 feet long (245cm). Loch Ness Monster watchers believe it is a Plesiosaurus that haunts the Loch, revealing its huge head, neck, and tail from time to time.

How Does It Work?

This toy presented more problems than any other toy that I’ve designed (it’s also, I believe, my most sculptural and honestly my best toy design), so approach it with patience. There are several particularly tricky areas.

The head moves gracefully from side to side by means of two oval wheels tipped sideways on the front axle. The head piece pivots in the neck area, and a ¼" (6mm) dowel extending down between the two diagonal oval wheels moves the rear of the head piece back and forth, making the head itself snake to the right and left. There is also a 1" (2.5cm) wheel at the rear of the piece to reduce friction and let it move freely (see Figure 23.1).

The flippers are moved up and down by short pitman arms attached to the wheels (see Figure 23.2).

The Body

The body is made of three pieces: the base (A-1" [2.5cm] thick), the top of the body (B-1¼" [4.4cm] thick), and the top or ridge piece (C-1¼" [3.2cm] thick). Reference the top of piece B to help with the shaping of piece C.

To make the base, lay out pattern B on a 1" (2.5cm) piece of stock. The axles must be perpendicular to the parallel edges of the (jointed and ripped) board. Transfer the axle locations to one edge of the board. The axle holes should be a little below center to accommodate the small

wheels and still hold the body off the ground. With the piece clamped at a perfect right angle on the drill press, drill the two axle holes. Remove the rectangular area over the front axle by drilling all four corners of the rectangle and cutting out the waste with a jig saw or a coping saw. With the band saw at a 45-degree angle, cut out the silhouette of the body base.

Now, lay out the reverse body pattern (upper body piece A) on 1¼" (4.4cm) stock. With the band saw table perfectly square to the blade, cut out the silhouette, removing the cavity where the head enters the body and pivots.



The pitman arms, mounted on the wheels, push the flippers up and down to make Nessie swim.



The two oval wheels mounted on the front axle are used to sway the head from side to side.



This wide toy requires long front and back axles that extend through the body to the wheels.



Figure 23.1. As the axle turns, the ovals tip one way and then the other, moving the head and neck back and forth by means of the peg that rides between the ovals. (Note the 1" [2.5cm] wheel reduces the friction and helps the head move more easily.)

Make a pencil line all the way around the silhouette, $\frac{3}{8}$ " (1cm) from the bottom edge. You may want to lay the piece on top of the body base to make sure you are measuring from the lower edge for the pencil line. This $\frac{3}{8}$ " (1cm) will make the flat surface to attach the flipper hinges.

This cut does not enter the cavity, but ends just before it turns to go back into the cavity. With the band saw at 45 degrees, cut along this pencil line, leaving a $\frac{3}{8}$ " (1cm) flat ridge all the way around the bottom of the upper piece.

Edge sand the side of the neck cavity; this area will be visible after assembly.

Lay the upper body piece upside down on a $1\frac{1}{4}$ " (3.2cm) piece of stock and mark a line where the pieces meet. This is the outline of the ridge piece. Cut this out on the band saw with the table at a 45-degree angle. There will be little support under the piece

as you finish the cut. This will make it impossible to correct sloppy cuts, so make sure the cut is good before you cut the final edge and release the piece.

Now you can glue the body together. Start by gluing the two large pieces together, using two large boards as clamping surfaces (see Figure 23.3). Notice the additional clamp on the tail where the boards don't touch.

Edge sand the $\frac{3}{8}$ " (1cm) flat surface that goes all the way around the body (for the hinge attachment) with the table at 90 degrees. Then, with the table at 45 degrees, sand the underside edge of the body.

The easiest way to sand the top surfaces of the body is to use the edge sander freehand. You can feel when the entire surface is touching the belt. Move the piece in smooth fluid sweeps around the curves. You should be able to remove all the saw marks this way, too.

Round over the top piece to about 60 degrees by hand on the edge sander (the band saw won't tilt beyond 45 degrees). Take the same amount off of both sides, keeping an eye on the ridge line. It should end up in the center.

Last, a good bit of hand sanding in the direction of the grain will take off all the crossgrain sander marks and soften the edges.

The pivot hole can now be drilled from underneath. Put axles through the body temporarily. You can rest the axles on two boards of equal thickness to support the body parallel to the drill press table (see Figure 23.4). This hole must be accurate, so use a brad point or Forstner bit to prevent wandering. Set the depth so that the $\frac{3}{8}$ " (1cm) bit will go through the bottom piece into the upper ridge piece without going through.

The Head and Neck

When you transfer the head pattern onto your stock, carefully mark the center of the holes on the sides of the piece. Drill and plug the eyehole and flat sand the unmarked side of the piece so it lies flat on the band saw table. Cut out the silhouette on the band saw. Use a square to transfer the hole locations from the side to the top, bottom, and rear of the piece for the pivot hole, the wheel peg hole, and the hole for the $\frac{1}{4}$ " (6mm) dowel that sits between the oval wheels. Before you drill these holes, put the head piece in place with the body upside down. When you sight from the pivot mark down through the $\frac{3}{8}$ " (1cm) hole, the $\frac{1}{4}$ " (6mm) hole will be directly over the front axle. Check to make sure there will be room for the $\frac{3}{8}$ " (1cm) wheel behind the piece.

Drill all of these holes carefully, making sure they are all square to the drilling surface. Flat sand and edge sand the head piece.

Cut out the two neck sides, trying to match the grain direction with the head piece. Lay the neck

sides on either side of the neck and mark where they meet the head piece, front, and back. Router the silhouette of the head piece, stopping short of where the neck sides will be joined. Flat sand both sides of the neck side pieces and edge sand the curve in the rear of these pieces. Before assembly, round over these edges with a four-in-hand rasp and sandpaper.

Glue the sides to the neck, and, when the glue has set up, edge sand the upper and lower edges, where the pieces have a common edge. With the piece upside down on the band saw, cut the sweeping curve on both sides of the head to taper the neck out to the added pieces.

Turn the piece over and mark a $\frac{3}{8}$ " (1cm)-wide strip down the middle of the top of the neck (two pencil lines). With the band saw table at 45 degrees,



Figure 23.2. The pitman arms are attached to the side of the wheels (off center) so they lift the flippers on their hinges as the wheels turn.

cut along this line. Start at the outside edge and curve into this line, follow it, and then curve smoothly out at the other end.

These angled cuts can be sanded on the sander/grinder. Then hand sand with the grain to remove any crossgrain sander marks and soften the edges. Don't glue any of the dowels or pegs until assembly.

The Flippers

Lay out the flippers and cut them out with the band saw. Locate and drill the holes for the attachment of the pitman arms. First, drill a $\frac{1}{2}$ " (1.3cm) hole, leaving $\frac{3}{4}$ " (8.5mm) or less at the bottom of the hole. Then drill a $\frac{1}{2}$ " (7mm) hole the rest of the way through. To increase the ability of the peg to pivot, slide the hole up onto the drill bit while it's

running and pivot the piece around in a circle at about a 45-degree angle (see Figure 23.5). This step can also be done with a small round file. Your goal is to create a hole that is $\frac{1}{2}$ " (7mm) in the middle but larger at the top and bottom.

Be careful not to mar the edges of the $\frac{1}{2}$ " (1.3cm) hole as a $\frac{1}{2}$ " (1.3cm) plug will have to fill the hole cleanly.

Next, flat sand, edge sand, and hand sand the flippers. The pegs that go through the flippers need to pivot freely, so plugging the holes is tricky. Make the $\frac{1}{2}$ " by $\frac{1}{4}$ " (1.3cm by 6mm) plugs with a plug cutter (and the same material as the flippers) or $\frac{1}{2}$ " (1.3cm) dowel rod. With the peg in position, glue the plugs in place with the grain direction matching if you made crossgrain plugs. They should only stick about $\frac{1}{8}$ " (2mm) in the hole; be careful



Figure 23.3. You can use two boards to spread the pressure out and provide clamping surfaces as you glue the two main body pieces together.



Figure 23.4. If you put dowels through the axle holes and rest them on thick scraps of equal thickness, you can drill the pivot hole accurately on the drill press, in spite of the awkward shape of the piece.

not to get any glue on the peg head. When the glue has thoroughly set up, sand the excess plug material back to the surface of the flipper.

Transfer the mark on the inside bottom edge of the flipper from the patterns. This is the center of the hinge. When you lay out the hinge screw locations, leave the barrel off the edge of the flipper, and make sure the hinge is perfectly square to the edge of the flippers. The size of these holes is critical. If they're too big, they won't hold firmly, but if they are too small, the soft brass screws will snap off in the hole and you'll be in real trouble. I recommend drilling a hole in a scrap and trying the screws in that first. Drill all the holes, being careful not to go through the flippers.

Mark a line directly over the axle holes on the body. Use these lines to locate the hinge positions on the $\frac{3}{8}$ " (1cm) ridge that goes around the body. Drill these holes as well.

The Wheels, Oval Drive, and Pitman Arms

Manufactured wheels won't work on this guy because the outer edge needs to be beveled to accommodate the flippers' downward stroke.

Use a hole saw, band saw, or jig saw to cut out the wheels (J). In either of the sawing cases, you should drill out the axle hole first to prevent splitting the small pieces after.

Mark a line $\frac{1}{2}$ " (1.3cm) up from the bottom edge of the wheel(s) all the way around. Then, with the table on the jig saw or scroll saw set at 45 degrees, cut around the wheel, making a bevel.

If you're very careful, you can sand this beveled edge (and the vertical edge) on the sander/grinder with the table set at 45 degrees. Sand gently and quickly to avoid taking the wheel out of round, or simply sand the edges by hand.



Figure 23.5. Flair the hole in the flipper outward (top and bottom) by tilting it around in a circle while it is on the drill bit.

To drill the peg hole(s) in the wheel(s), put a plug (a piece of dowel) in the axle hole without glue to prevent the hole from collapsing as you drill the hole right next to it.

To make the tipped oval wheels (J), cut a 2" (5.1cm)-thick scrap at 30 degrees on the band saw. Use this for support as you drill the axle hole with a Forstner bit at that same angle. Hold the piece firmly to the scrap as the bit passes through the wood. Now, lay out the oval around the hole, noting that the edges will be the same distance from the hole two-thirds of the way around and then will be farther away for the rest of the circumference. After the wheel is cut out, flip it over. The wheel should be identical in reverse, with the edge equidistant from the hole two-thirds of the way around. Don't hesitate to make them over, as it is essential that they be perfect. The pitman arms (H) must also be precise. It's a good idea to attach them to the toy without glue and adjust the length as necessary.

Cut a strip of wood $\frac{3}{8}$ " x $\frac{1}{2}$ " x 14" (1cm x 1.3 x 35.6cm). You'll want to make a couple extras in case one or two get messed up in the drilling process. Lay out six pitman arms with a space between each one, and drill the peg holes before cutting them to length. This way you can prevent splitting and account for any drill bit wander by cutting to the appropriate length.

Cut off the pieces square to the length. Clamp them in an upright position on the drill press and drill perfectly centered peg holes into the end grain. Tapping a nail or a center punch in the hole location first will help make the holes more accurate.

This next operation takes some care. In order for the pitman arm to pivot freely on the peg that attaches it to the wheel, the lower hole needs to be flared (inside and out) in the same fashion as the hole in the flipper (see Figure 23.5).

Now for a little careful work on the sander/grinder. The bottom of the pitman arms is simply rounded (fore and aft), leaving the same amount of material around the bottom half of the hole. The top of the arm gets a rounded bevel on all four sides. Be careful not to shorten the piece in the process. Finally, hand sand all the edges.

Assembly

All stages of assembly should be done without glue first.

Peg the pivot wheel on the rear of the head piece and slip the piece into the body. Put the $\frac{1}{4}$ " (6mm) dowel in the underside of the head piece and then put the $\frac{3}{8}$ " (3mm) dowel through the body and head piece. Leave the dowel long so you can remove it after the trial assembly. Note any adjustments and remove the head piece and make corrections. Now, cut the front axle to $8\frac{1}{2}$ " (21.6cm) long (2" [5.1cm] extra) and slip the ovals on as you pass it through the body.

Hold a $\frac{1}{4}$ " (6mm) dowel straight down between the two ovals and twist the axle to see how far apart the ovals must be set not to bind up on the $\frac{1}{4}$ " (6mm) dowel. You want to get the ovals as close as possible without binding up on the dowel.

Once you've figured out the best position for the ovals, glue them in place by putting glue onto the axle and sliding them over onto the glue. Then, using a glue applicator or a toothpick, put a bead of glue around the axle on both sides of each oval. Make sure they are identically tilted, positioned where they will work, and perfectly centered on the dowel.

When the glue has dried thoroughly, position the head piece as in the first trial run and try twisting the axle to see if the movement is smooth. Make any adjustments necessary. Now, glue and peg the pivot wheel in place. With a glue applicator or a toothpick, put glue in the $\frac{3}{8}$ " (1cm) hole in the top of the body for the $\frac{3}{8}$ " (1cm) pivot dowel. Slip the head piece into the body and glue the $\frac{1}{4}$ " (6mm) dowel into place. Then slide the $\frac{3}{8}$ " (1cm) dowel up through the body and the head piece. Tap it into the glued hole and cut off any excess.

The next operation is quite critical, so take your time and make sure it's done perfectly. With the body upside down, twist the axle until the oval is tilting side to side (fore and aft, not up and down). The head needs to point straight forward, so move

the axle until the head is pointing directly forward. If you pinch the axle between your thumb and forefinger, right next to the body on either side, and twist it back and forth, the head should move to one side, then the other, and then return to center.

Once you have the ovals perfectly centered, mark the axle ends to be cut off. Leave a gap next to the body equal to the thickness of the wheel plus $\frac{1}{16}$ " (2mm). Cut off the ends of the dowels.

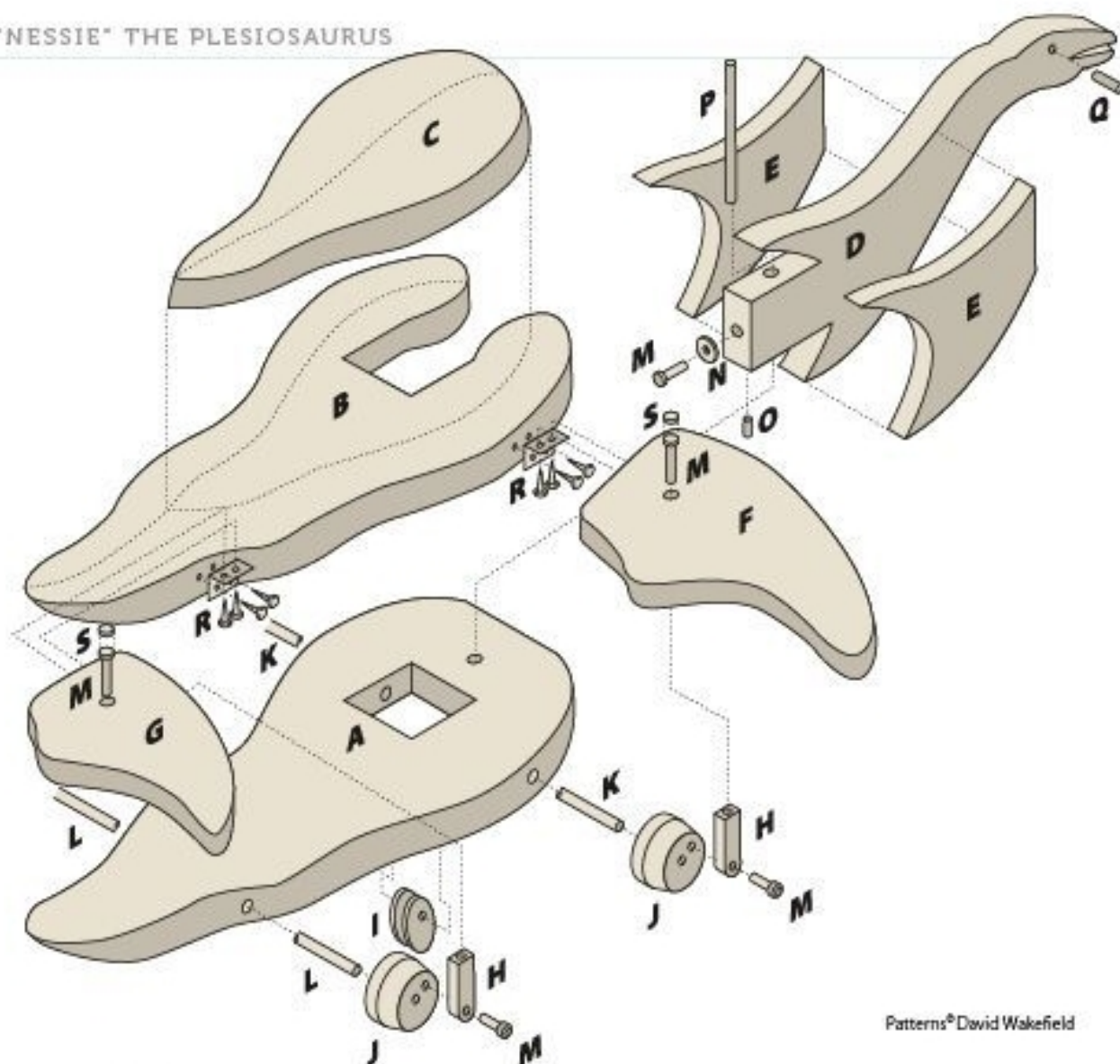
Because of the position of the hinges, the flippers will have to be screwed in place before the wheels are put on. To prevent the holes from collapsing, carefully put the pegs in the wheels without glue as you glue on the wheels. Make sure the pegs are identically positioned (either both up or both down). Remove the pegs.

Cut the rear axle to length, leaving $\frac{1}{16}$ " (2mm) space on both sides of the body. Glue on the rear wheels in the same fashion as the front wheels and remove the pegs. When the glue has set up, sand the outside of the wheels by hand to remove the glue and smooth the ends of the axles.

The last operation can be quite frustrating. If everything has been cut and drilled precisely, and you're lucky, the pitman arms may work perfectly on the first try. Or, you may have to make them over to get the length perfect. At any rate, a dry assembly is essential. Be careful not to push the peg too far into the top of the pitman arm, as this will inhibit the pivoting action. The same is true for the pegs that go through the pitman arms into the wheels.

Note also that if the pitman arm is too short, the flipper will hit the surface on which the toy is rolled; if it is too long, it will bind at the top of the cycle. The flipper should come just short of hitting the surface.

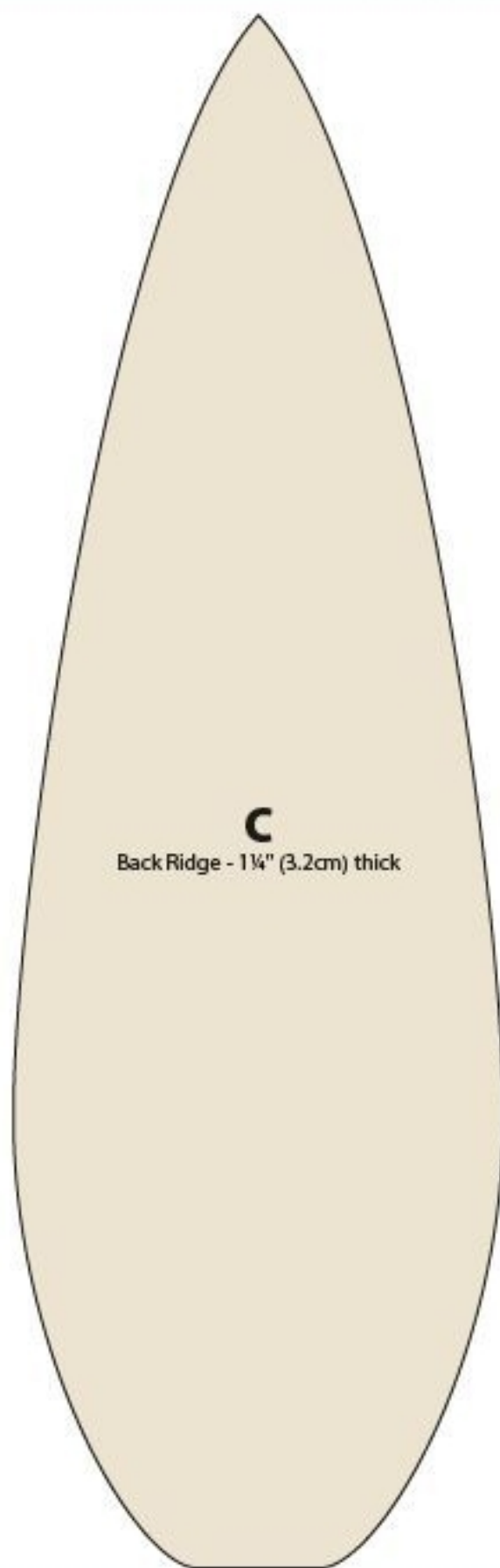
Now that the arms are all the perfect length, glue all the pegs into the wheels and pitman arms. When the glue is dry, oil him up and away you go. The Loch Ness Monster lives!



Patterns © David Wakefield

Materials

Part	Description	QTY	Thickness	Width or Diameter	Length
A	Body Bottom	1	1" (2.5cm)	5½" (14cm)	15" (38.1cm)
B	Body Top	1	1¾" (4.4cm)	5½" (14cm)	15" (38.1cm)
C	Back Ridge	1	1¼" (3.2cm)	3" (7.6cm)	9½" (24.1cm)
D	Head	1	¾" (2.2cm)	3½" (8.9cm)	13¼" (33.7cm)
E	Neck Sides	2	¾" (1cm)	3½" (8.9cm)	5¾" (14.3cm)
F	Front Flippers	2	¾" (1cm)	2¾" (6.7cm)	5¼" (13.3cm)
G	Rear Flippers	2	¾" (1cm)	2¼" (5.4cm)	4" (10.2cm)
H	Pitman Arms	4	¾" (1cm)	¾" (1.6cm)	2½" (5.4cm)
I	Oval Wheels	2	¼" (6mm)	¾" (1.9cm)	1¾" (3.5cm)
J	Wheels	4	½" (1.3cm)	1½" (3.8cm)	—
K	Front Axle	1	—	¾" (1cm) diameter	6½" (16.5cm)
L	Rear Axle	1	—	¾" (1cm) diameter	4½" (11.4cm)
M	Pegs	9	—	⅜" (5.5mm) diameter	1⅞" (2.7cm)
N	Head Roller	1	¾" (1cm)	1" (2.5cm)	—
O	Roller Pin	1	—	¼" (6mm) diameter	½" (1.3cm)
P	Head Pivot Dowel	1	—	¾" (1cm) diameter	2¾" (6.7cm)
Q	Eye	1	—	¼" (6mm) diameter	¾" (2.2cm)
R	Hinges	4	—	¾" (1.9cm)	1" (2.5cm)
S	Flipper Plugs	4	⅞" (2mm)	½" (1.3cm) diameter	—



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