Plans for building a Budget Yarn Ball Winder

By Greg Millar

Section 1: Introduction

1.1: Introduction

This project was undertaken in an effort to produce a sturdy, functional, and inexpensive yarn ball, or yarn cake, winder. The aims for the project were to produce the winder with under $40 in out-of-pocket expense and utilize shop scrap, widely available salvaged parts, and inexpensive hardware to build it. Further, there is a focus in this project to utilize tools that are themselves inexpensive, though perhaps less than ideal for the task. From the functional side of things, the winder should be able to wind a one pound ball that is stackable and center pull without binding or tearing the yarn. The winder will be hand operated and somewhat portable as it will clamp to whatever work surface you’re using.

In many situations I’ll be providing information on using the bare required tools as well as tools that are more suited to the task. In most cases, while I’ll illustrate the use of the bare essential tools, I’ll personally be using more suitable tools if I have them. I will occasionally suggest optional or alternate steps that I will explain as best I can, though the main path of the project I will assume you have all the parts and tools that I’ll be using. An example of this is that I suggest at many points that a scroll saw or band saw would be suited to many of the cuts I do, but as I own neither of those, I do not provide detail as to their use in the project. By and large, however, if you do own one of those two tools, you’ll likely know how to use it for the task at hand anyway.

Since this project is aimed at providing instruction for those who may be unfamiliar with woodworking, you’ll find that I will often describe steps that may be obvious for the seasoned tinkerer or woodworker.

Since this design is going to be fairly utilitarian, expect aesthetics and refinement to take a back seat to ease and functionality. For instance, while it would be elegant to use gearing to achieve an exact rotation of the offset spool, such a mechanism is overly complicated and expensive. A wheel coupled to a fixed acorn nut provides a less exact or aesthetic solution, but is far easier to implement. In a future project, I plan to build a winder with a focus on aesthetics and all-around build quality, likely utilizing expensive parts and more specialized tools.

Since the project is based partially on economy of the build, I’ll be including estimated costs for most materials.

1.2: Tools

Here is the list of all the tools I recommend having. If you’re just an occasional tinkerer, I recommend buying inexpensive tools as you will get better value out of their use. For the more serious, project
oriented worker, spend the extra money to buy good tools as it pays off in the long run. If you're trying to save money on tools, corded tools generally cost less than cordless, and rummage sales can be a great source of inexpensive tools. Before buying a cheap power tool from a discount dealer please do some research online first. While some budget tools work just fine, others aren't even worth the parts they're made from.

1. A Hand Saw – These are very inexpensive. Unneeded if you have a circular saw or similar for making bigger cuts.
2. Ruler/Straight edge - preferably metal
3. Compass - Somewhat optional, but highly recommended. Unless you plan to do a lot of drafting, just pick up a cheap one.
4. Pencils
5. Permanent marker - Optional
6. Keyhole Saw or Hacksaw - Optional, but recommended. They are not very expensive.
7. Coping Saw – You can snag a 6” depth coping saw for pretty cheap. You won't need this if you have a jigsaw, band saw, or scroll saw.
8. Tape Measure – Cheap and necessary.
9. Clamps: You’ll need at least 3x 6” C-clamps. I also recommend a few small bar clamps to make life easier. Clamps are necessary, cheap, and you can never have enough of them.
10. Power drill - Corded or cordless. A hand drill could probably be used, but I really recommend something electric. A low-end corded drill can be obtained pretty cheaply. I do not recommend the cheap, battery-in drills as they are very lousy and take forever to charge.
11. Spade Bit set – Optional, but likely any multi-purpose bit set you buy will have a few of them. They're cheap when purchased individually too.
12. Drill bits – You'll need a fair variety of these. A multipurpose set will cover most of your needs without costing much.
13. Hammer – Somewhat optional, but everyone should have a hammer.
14. Quick Square – Optional, but these are incredibly cheap and very useful.
15. Sandpaper – You’ll need at least one coarse grit and one medium/fine grit. A 60 or 80 and a 100 or 120 would suffice. Unneeded if you have a random orbital sander.
16. Jig Saw - Optional but HUGELY helpful. It saves a lot of time over using the coping saw. These can be picked up fairly cheap and are useful in a wide range of projects where extremely fine cutting is not needed. If you have a jigsaw you'll want some fine work blades for cutting curves.
17. Forstner Bit set - Optional, but they save a lot of time. You can pick up a low-end set for a modest amount of money (about the same price as a cheap 12v cordless drill). You can also buy individual bits, which might fit the budget better if you only need one or two.
18. Circular saw – Optional. They’re not terribly expensive, but pretty handy to have.
19. Precision screwdriver set – This is only necessary if you’re using a hard drive motor as your bearing for the crank barrel. These are pretty cheap too.
20. Random orbital sander – Optional. Of all the tools, this is one of the most expensive to procure. It helps if you’re doing a lot of sanding, but I wouldn’t buy one just for this project.
21. Socket set – You can snag these cheap at discount hardware stores or a yard sale.
22. Crescent wrench – Again, these can be acquired fairly cheap.
23. Rasp – Useful for cleaning up holes where you used the “drill trick.”
1.3 Materials

For this project I was able to supply the wood entirely out of my pile of shop scrap and a lot of the hardware was from my shoebox full of leftover hardware from other projects. I was also able to find a lot of parts from various scavenged sources to further reduce cost. That said, I did stop by the hardware store and price out most of the parts used in the winder. Freecycle and other local material sharing groups are great resources to help you save money.

1. 26”x14”x3/4” piece of plywood – Construction grade plywood can be acquired free if you ask around enough. Otherwise you can snag a 4x4 piece for about $8. I had shop scrap laying around for this wood.
2. 4x 12”x12”x1/2” pieces of plywood – Again, construction grade plywood should be easy to acquire for free, but otherwise a 4x4 piece runs about $6. Again, I used shop scrap.
3. 3”x10”x1/2” piece of plywood – Can be cut out of the piece above.
4. Some sacrificial wood for drilling – Use shop scrap or any junk wood you can find.
5. ½” x 6” bolt – This bolt, and the other ½” hardware below was $3.50 total.
6. 3x ½” washers
7. 2x ½” nuts
8. 12” length of ¾” inner diameter PVC pipe (to fit the bolt) – I picked up a 2 foot length for $1.25.
9. 3x 608z skateboard/roller blade bearings – I paid $8.57 online for a set of 8.
10. 12” long piece of ¼”x20 allthread – I found a piece for $1.
11. 3x 608z skateboard/roller blade bearings – Hard drive motor and platters were acquired for free. A Lazy Susan bearing costs about $6.
12. 10x ¼” washers
13. 4x ¼” locking washers
14. Hard drive motor with spacers (see my Hard-Drive motor extraction tutorial) or Lazy Susan bearing – Hard drive motor and platters were acquired for free. A Lazy Susan bearing costs about $6.
15. Hard drive platter (metal platter only)
16. Wood glue – I had some on hand, but you can snag a small bottle for $1.
17. 6x screws (for attaching the platter to the crank barrel. Any screw under 2” long will work) – I had these laying around, but you can get a small pack of screws for $1 or less.
18. 2x 90º angle brackets under 4” long – I paid $0.80 total for the two brackets.
19. 4x ¼”-⅝” long machine screws – $0.80 for a pack of 12.
20. 1 discarded bike tube (these can be acquired free from a lot of bicycle repair shops. Just go in and ask if you can have any of their damaged tire tubes, they’ll likely have a box full waiting to be picked up and recycled). - Free
21. Pliant Glue designed for rubber (Shoe Goo works great here) - $5 for a bottle
22. 2x 2” c-clamps – Found a pair of these for $3 total.

Total if you buy everything: about $55.
Amount I actually spent: $18.92.

Had I been more patient, I would have spent less than $15, as I found the PVC pipe, the ½” hardware, and the allthread from a free source a few months after I’d already purchased them from the store. The 608z bearings also dropped several dollars in price about 6 months after I bought them, so it goes.
Section 2: The Base

The first thing you’ll need to do is decide on the piece you want to use as your base. For the guide I’ll be assuming that like me you are going to be making a base that is 26” long by 14” wide with rounded ends. For my case, I had a 24” by 48” by ¾” piece of shop grade plywood left over from a shelving project, so I pulled that out and cut off a 26” piece (Fig 2.1).

While I am pictured using the saw, which you can do, I’ll admit that after the picture I grabbed my circular saw and made the cut. I own a circular saw so I’m going to use it. I suggest you do the same if you own one. Anyway, if you’re going to use a hand saw, make sure to draw your line just a little bit wide of where 26” is, as your cut will probably wander a bit. You can sand or plane off the difference later.

Since my piece was still big (24”x26”), I did another cut bringing it down to the required 26”x14” (Fig 2.2).

Next you’ll need to find the two center points for the crank and the spindle. There are many ways to go about doing this, but in order to make it as simple as possible I’ll be using a more approximate way. First you’ll need to measure the width of your piece and get a more exact number for its width. In my case I had it at 14” pretty well exactly. So take half that and mark it on two points on either side of your board (Fig 2.3). This will give you the halfway point on both sides of your piece through which to draw a line.

Measuring along the center line is cheesy, and not the greatest way to do it, but it works. In our case, since this is a kludge project, such a method would work just fine. However, I like to have a cross hairs rather than just a mark on a line, so I did something a little more exact (Though still not as exacting as I could be). I measured 7” in on two points from the end of board (Fig 2.4). Then I drew a line through these two points, giving me...
an “X” to make my center of rotation (Fig 2.5). Once you’ve done one side, do the other side so you have both your center points marked.

At this point, you could really consider the base is mostly done. The next step is really for aesthetic purposes, and if you’re fine with a rectangular base, it could be skipped. Otherwise the next step in my project is to create the rounded ends for the base.

In my design I rounded the ends by using a circle just 2” bigger in diameter than the crank. Since my crank is designed to be 12” in diameter (6” radius), the base will have each end being a half circle that is 14” in diameter (7” radius). The first step to rounding the ends is to draw a half circle that is 7” in radius. The easiest way to accomplish this is with a compass that can draw a circle with a 7” radius (Fig 2.6).

However, my compass isn’t that big. The biggest circle my compass will draw is one with a 6” radius, and since I don’t want to go buy another compass I have to use a trick in order to draw my 7” radius circle.

To do this, you’ll need a small nail, and some string or twine. First, drive the nail into the board at the center of the circle (Fig 2.7).

Next, take your piece of string and loop it around the nail, pulling the ends off the end of the board along the center line you drew earlier. You want to tie a square knot so that the inside of the knot is just on the board (Fig 2.8). Once you have the knot, test the string’s length by putting your pencil in it and pulling. The tip of your pencil should just sit on the edge of the board when positioned along the line. Clip off the ends of the string and now you have a loop that when double is about 7” in length.

To draw your half circle, you slip the loop over the nail and put your pencil in the other end of the loop. Stretch the loop until it’s tight and then place your pencil on the wood. Try to keep your pencil as perpendicular to the wood as possible (fig 2.9).

Once you’ve got yourself ready, just draw along the wood using the string to guide your pencil in the circular motion. When you’re done, you should have a half circle (or a little more) outlining where to make your cut (fig 2.10). Do this on both sides.

Now that you’ve got your line, it’s time to cut your ends so that they’re rounded. If you’ve got a jig saw, pull this out and fit a fairly narrow blade so that you can make the turn. Otherwise grab the coping saw.

Start at the edge of the wood and cut along the line (Fig 2.12). If you’re using a coping saw you may need to stop and cut off some of the waste before continuing to get it out of your way (fig 2.13). Do this for all 4 corners and then you’re ready for the next part, drilling the hole (Fig 2.16).
To set the hard-drive into the base, you’ll first need to know how big to make the hole. Grab your hard drive motor and flip it over. There should be a round cylindrical section that’s pushed up from the flange. Measure this across to find the diameter of the hole you’ll need to make (Fig 2.17).

Once you have this measurement there are a few ways to proceed. With the bare essential tools, you’ll have to first draw the circle you want to cut out on the wood with your compass (Fig 2.18).

Now grab your drill and a fairly good sized bit. In this case I used the 3/8” drill bit from my bit set. Now you’ll want to drill holes all the way around the inside of this circle. You’ll want to space them out a little bit as otherwise they’ll catch and cause problems (Fig 2.19).

Once you have all your holes drilled you’ll have to cut them out. You can use a keyhole saw, or better yet a coping saw blade gripped between two pliers. Just be careful about bending the blade when doing that. A jig saw is a great tool to use here as well.

Alternately, if you have the forstner bit set (or if you want to buy a bit to us use on the project), you can make this hole in one easy step. In this case I grabbed my 1.5 inch forstner bit (fig 2.20) and centered it on where I wanted the hole. Usually when using forstner bits you should be using a drill press on a low speed. The drill press assures that you’ll have good control over the bit, you’ll be able to keep even pressure, and that you’ll be driving the bit at exactly 90°. However, I don’t own a drill press yet, so in this case I just chucked the bit into my cordless drill and set the drill to its lowest speed on direct drive.

Be very careful when doing a hole this way. The forstner bit will take a lot of wood off pretty quickly, and it tends to heat up. Take short, shallow cuts and let the bit cool a little between cuts. You’ll also need to put quite a bit of pressure on the bit to get it to cut, so lean into it! Stop every so often to check the hole for fit against your hard drive motor.

The other benefit to using a forstner bit is that once the hole is deep enough, you can stop and not drill through the wood. In this case once the hole was about 2/3 of the way through the board it was deep enough, so I stopped drilling (Fig 2.22). I can set my hard-drive into the hole and you can’t see it from the bottom. Easy AND more attractive; a win-win solution. If you’re using a ½” thick piece of wood for this project, you’ll want to put a second piece of scrap wood under the drill site just in case you go all the way through. Forstner bits have an unfortunate tendency to blow-out the bottom of whatever you’re drilling if you don’t add a little extra thickness to keep the cut smooth.
You could also use a 1½” spade bit or a hole saw, but in those cases the hole would go all the way through, so they are still not quite as nice as using the forstner bit.

I double checked that my motor fit with the flange flush up against the surface of the wood (Fig 2.21), and seeing that it was I unchucked the forstner bit and cleaned up. The base is now complete, aside from some sanding and attaching the motor, which I’ll be covering in a later chapter when the Yarn Ball Winder is ready to be assembled (Fig 2.24).

In general I find it good practice to save sanding/painting until the very end of a project if possible. If you need to change the project or you accidently drop something on it, it’s nice to not have sanded and painted it already, since you’ll just have to sand and paint again anyway.
Section 3: The Crank

This section, while fairly simple to construct, is surprisingly complex from the measurement standpoint. There are a lot of measurements that need to be rather precise in order to pull the whole thing off.

Before you begin construction there are a few measurements that you will need to make so that you can properly size several of the cuts for this section. The first is the belt that will be used to convert the power produced by the crank barrel to the rotational speed of the primary rotational axis. In my case, I’ll be converting an old bike innertube into a drive belt by creating a lap joint and then folding it in half. In order to know how big the groove on the crank barrel is going to need to be, the width of the belt needs to be measured (Fig 3.1). In this case my belt will be 7/8” wide, so a 1” channel should be sufficient. To accomplish this, 2 pieces of ½” plywood stacked together will work, which I’ll show later.

You will also need to measure a lot of the hardware that is going to be used in the crank barrel. Specifically the diameter of the ½” bolt shaft, the diameter of the ½” washer, the diameter of the hard-drive spindle cap, and the hard-drive platter (those last two are not needed if you’re using a Lazy Susan bearing). The table below summarizes these measurements (See Figs 3.2-3.6 for illustration of these measurements):

<table>
<thead>
<tr>
<th>Item</th>
<th>Diameter</th>
<th>Closest Bit Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bolt</td>
<td>1/2”</td>
<td>1/2”</td>
</tr>
<tr>
<td>Washer</td>
<td>1 3/8”</td>
<td>1 3/8”</td>
</tr>
<tr>
<td>Harddrive Spindle Cap</td>
<td>1 5/16”</td>
<td>1 3/8”</td>
</tr>
<tr>
<td>Harddrive Platter</td>
<td>3 7/8”</td>
<td>N/A</td>
</tr>
</tbody>
</table>

The “closest bit size” column is to pick out which forstner bit or hole cutting saw you’ll need to use to make your holes (provided that you are using one of those). Since the platter doesn’t need a hole, it is marked N/A.

I’ve included the measurements of my parts below, I highly recommend using your own measurements, I’ve just included mine as an example and to show where I’ve gotten my numbers:

<table>
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</tr>
<tr>
<td>Hard drive Platter</td>
<td>3 7/8”</td>
<td>N/A</td>
</tr>
</tbody>
</table>

I lucked out and the washers I purchased were very similar in size to the spindle cap of the hard drive, so I would only need to use one forstner bit for all my drilling; saved me a lot of re-chucking bits when doing the drilling.

Now that we have our measurements, it’s time to do all the layouts for the pieces we need to cut. First grab the stack of 12”x12”x½” plywood and mark the center of each 12”x12” board. The easiest way to do this is to grab a reasonably straight object that’s long enough to go diagonally across the boards and
draw two lines connecting the diagonal corners (Fig 3.7). This will be a pretty close approximation to the center of the board, and since this is a kludge project, reasonably close is all we need.

From there you need to draw a 12” diameter (6” radius) circle on two of the boards and an 11 ½” diameter (5 ¾” radius) circle on the other two boards (Figs 3.10-13). The best way to do this is with a ruler and a compass, otherwise you can use the string and nail trick as described in section 2.

Now you need to draw yourself the holes you’ll be using for the handle. On all the pieces put a mark at 10 1/8” inch from the center (use the compass set to 5 1/16” radius, or the string and nail) (Figs 3.14-17). On one of the 11 1/2” piece draw a circle matched to your bolt tool diameter on the 10 1/8” mark. In my case my ½” bolt was indeed ½” so I drew a ½” circle (Fig 3.18). Now, on both pieces with the 12” circle and the remaining piece with the 11 1/2” circle, put a circle matched to your washer tool size centered on that mark. In my case I used a 1 3/8” circle (Fig 3.19).

Next you’ll need to draw circles matching the bit size for your spindle cap on the center of each piece. In my case I drew a centered 1 5/8” diameter circle in the center of all 4 pieces (Fig 3.19). You technically don’t have to draw this circle, but I find I like having it as a reference, just so I’m not screwing anything up.

Finally, grab both your 12” circle pieces and mark one as the top, and one as the bottom. On the bottom piece, draw a circle matched to the diameter of your harddrive platter (Fig 3.20). This is for later reference so that you can center the platter. Since the platter has a hole in the middle, it is not recommended that you trace the platter on the wood. It’s better to measure the platter and use a compass to draw the line on the wood, as that will give you much better centering.

Take a moment at this point and double check all your markings. Line up your washers with the washer markings and check that the platter fits the circle you drew for it. If anything looks too small, remeasure and redraw your lines.

At this point all your lines should be ready to go, so it’s time to start cutting and drilling. It doesn’t really matter which order you do it all in, but I cut our the platters first and drilled the holes through them second. Grab your coping saw, or better yet the jig saw and cut out your disks (Fig 3.21). You’ll probably need to clamp it, cut off a corner, rotate, clamp, and cut again a few times to work your way around (Fig 3.22). Getting it perfectly circular isn’t a huge deal, but take it slow and get it as close to a circle as you can. Mine weren’t terribly close to perfect circles, but certainly close enough. This is where having a scroll saw...
and a disk or spindle sander would really come in handy, so if you've got those please use them. You could probably also use a template and a router, but that takes a lot of time and you still need a perfectly round template of correct size. Save the scrap pieces from your corners, you can use them later.

Now it’s time for some drilling. I highly recommend drilling one of each of your hole sizes into a scrap piece of wood and testing to make sure that everything will fit through the holes that you’ll be drilling for them. In this case I grabbed a piece of scrap and drilled a ½” hole for the bolt and a 1 3/8” hole for the washer and spindle cap. Everything fit, so I was ready to drill. If things don’t fit, check and see if it’s close enough for some sanding, and if not, go up a bit size and try again.

Once you’ve checked everything you can start drilling. I started with the center holes, but I recommend actually doing the ½” bolt hole first. You’ll probably need a ½” spade bit to do this (Fig 3.53). Please remember that when using spade and forstner bits to drill all the way through a piece, you should put a sacrificial piece of wood underneath. This prevents blow-outs from drilling as well as preventing damage to your work surface.

I started by drilling out the center hole of a piece and then doing the washer hole. Order isn’t really important. Having the forstner bits or hole cutting saw for these holes is extremely handy. However, you can use the hole cutting trick from section 2 to do all your big holes. It will take 20 times longer to make your holes, but does not require specialty bits (this process shown in figs 3.26-43). Again, I’ve got the forstner bits so I used one.

Once you’ve got everything drilled, test all the holes. Make sure the washers fit through their holes, and that the spindle cap fits through all the central holes(Fig 3.48). Sand where needed to make things fit.

Now that the drilling is completed, it’s time for some sanding; specifically the two smaller diameter disks. These are the disks that the tensioning belt will be riding on, so getting them smooth is rather important. Using your bolt and a clamp, line up the two middle pieces so that the centers are as flush as possible (Figs 3.54-3.61). Make sure when you put the bolt in you also stick a washer into your washer hole so that the handle holes line up. Use your finger and check to make sure the center holes are as flush as possible. Once you’ve got it clamped, double check your center hole one more time; it’s crucial that this hole be flush before sanding. Now snag a piece of fairly coarse (80 or 100 grit) sandpaper and go all around the outer edge, getting it as flat, smooth, and even as possible. It doesn’t have to be perfect, but try to at least get it so that the two pieces are flush with each other. A random orbital sander is a huge help here if you’ve got one; but sanding by hand isn’t by any means unrealistic here. Using a scrap piece of wood as a sanding block can speed things up considerably if you are hand sanding.
You will also want to sand the inside of all your holes (aside from maybe the ½” hole). Wrap some sandpaper round a dowel (or a broomstick) and smooth out all the large holes.

Now it’s time for to assemble the wood. You can either screw it together or glue it; I recommend gluing personally, but if you want to use screws I recommend screwing in from both sides so that you don’t tear out either side. For gluing, lay out all your pieces in the order that they’re going to be put together and get your bolt ready, you’ll be using the bolt to make sure your handle holes line up. You’ll also need 3 clamps, so get these ready; if you are using C-clamps or other clamps without boots you’ll also want to use some of the scrap for clamping blocks so you don’t leave dents in your project. Depending on the wood glue you use you may have to work pretty fast so get as much ready as you can before you start (3.63). When you are gluing make absolutely sure that the base piece where you drew the circle for the hard drive platter is facing out; if you glue this side you won’t be able to properly center your hard drive platter.

When you’re ready, start squirting glue. I’ve always found it better to squirt glue on both mating faces and then brush it out with a glue brush, paper towel, or cloth (Figs 3.64 & 65); however, you can just squirt and smush if you like. Get everything lined up as best you can then stick in the bolt and use the washers and bolt shaft to properly line up the handle holes (Figs 3.65-67). Now wipe out any glue from the central holes with a wet cloth or paper towel and use your finger to flush up the inner holes (Fig 3.68). These are the most important, so get them as perfect as you can. Once you feel good about the inner hole, put on the first clamp and tighten it down (Fig 3.69). Double check your inner holes, and if they’re still flush put on the second clamp (Fig 3.70). Now pull the bolt out and all the washers and put the final clamp on (Fig 3.71 & 72). Tighten all the clamps down as much as you can without breaking anything and wipe off any glue that has leaked out of the cracks with a wet cloth or paper towel (3.73). Check your central hole one last time, just in case. Now set it aside and let it dry, usually it’s about 24 hours for wood glue to set-up, but check your glue for exact set-up time.

Once the glue is set it will be time to attach the harddrive platter to the bottom. I recommend at least 6 screws to hold this plate on, as it will be the interface between the harddrive spindle and the wooden crank. There’s a lot you can do here to make perfectly centered and spaced holes in the platter, which I did. And you can try your hand at counter-sinking and what-not to get the screws flush. However, this is a kludge build and it’s all really unnecessary (Figs 3.74-81).

Chuck up a drill bit matched to whatever screws you are using and clamp the platter to a piece of scrap wood. If you’ve tested and verified the platter is metal (see my hard-drive disassembly tutorial), then it will most likely be aluminum and will drill easily without needing a special bit. Even so, if you’ve got one use a carbide or diamond bit, as drilling aluminum with a standard wood bit will dull it rather quickly. Drill your holes as evenly spaced as you can, but don’t sweat it too much, this disk won’t be visible (Fig 3.83).

Once you’ve got your holes drilled, move your platter over to the crank and center it using the circle drawn on the base. Clamp it if you have a clamp that will reach that far into the center. I don’t have a clamp that will reach, so I just set it on top and held it by hand. Drill through one of the holes into the
wood and put a screw in to secure the disk (Figs 3.85 & 86). Check and make sure the disk is still centered, and if it is, drill the opposite hole and put another screw in. Check your centering again, and if it is still good, drill the rest of the holes and knock in the remaining screws (3.87).

You can test fit the crank to the motor at this point, but provided you checked your holes earlier, you shouldn’t run into any problems here (Figs 3.88-90).

Finally, it’s time to assemble the handle. Put one washer on the bolt followed by a nut, and tighten the nut all the way to the end of the thread (Fig 3.91). Measure the distance from the top of the washer to the underside of the bolt head (Fig 3.92). Subtract 1/8” inch and use this measurement to cut a piece of PVC to size using either the hacksaw or the pipe cutter (Figs 3.93-96). If you use the hacksaw you will probably need to sand the cut end flat. The best way to accomplish this is to put a piece of 100 or so grit sandpaper on a flat surface and rub the end of the pipe across it (Fig 3.97). Once you’ve got it reasonably flat, remove the nut and washer from the bolt, put the PVC onto the bolt, and put the washer and nut back. Check the PVC to make sure it spins freely around the bolt, if not take it back off and sand it some more (Fig 3.98).

Now place the handle on the crank. Make sure you put a washer down into the holes on each side of the crank disc, then put the last nut on the bottom and tighten it up. You’ll have to use a socket on the bottom end and hold it with pliers, channel-locks, or a vice grips on the other (Fig 3.100). Tighten it fairly snug, but don’t go overboard as you can crack the wood.

At this point the crank is complete. Assembly to the base is covered in the final step after sanding and painting; though you can test fit it now if you like.

An optional step here would be to counter-balance the crank disk. When the crank handle is added it causes a mild shift in the central balance of the crank which could be compensated for by drilling out a cavity in the opposite side and adding lead weight or bird/buck shot. However, as the balance shift is not really that much, and the harddrive platter is fairly rigid, I didn’t feel the need to add the counter balance. As yet I haven’t observed any problems by omitting it.