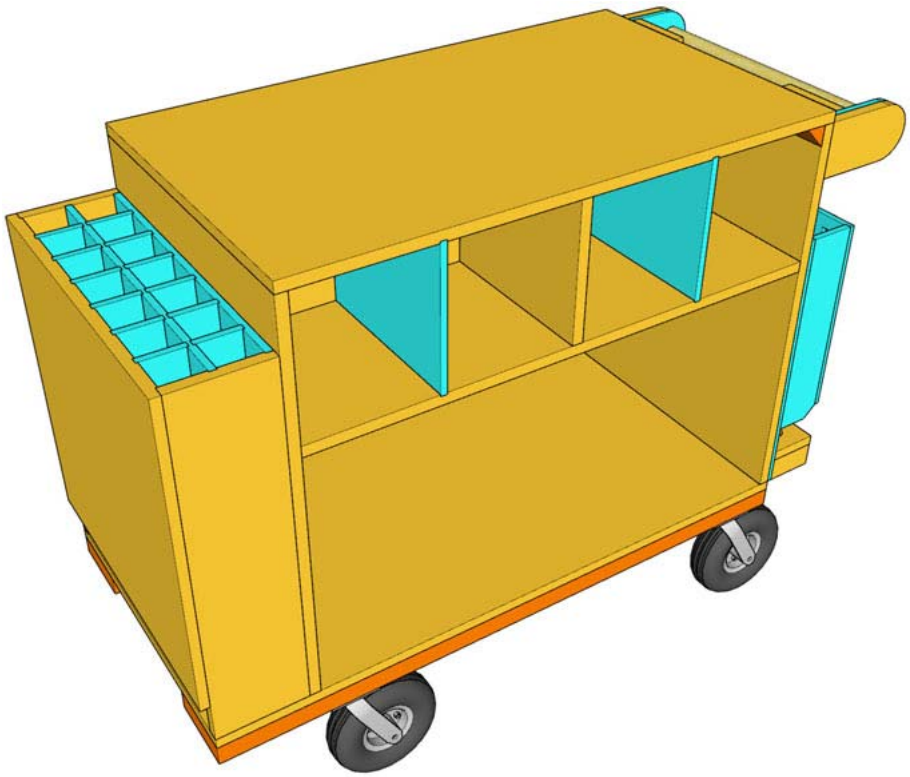
From ***BobPenoyer.com***

Baseball Equipment Cart



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A Warning – Please Read

Woodworking can be dangerous! It's up to you to determine if you can safely use the tools and perform the tasks needed to complete this and any other woodworking project. If you are unsure, STOP! Get advice from someone knowledgeable or do some careful studying on your own. Be safe!

Always wear at least an appropriate N95 dust mask or respirator when sanding or spraying paint. For advice about dust masks and respirators, visit this link:

https://woodworkingtoolkit.com/best-dust-masks-respirators/

READ, UNDERSTAND, AND FOLLOW ALL OF THE INSTRUCTIONS AND WARNINGS THAT CAME WITH YOUR TOOLS. BE CAREFUL!

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This Is Not Standard Documentation – Fill In the Blanks

I generated the original material in this ZIP package just for me, not for a general audience. This gave me the freedom to create a minimal amount of written design documentation. And it allowed the documentation to be technically incomplete. I simply carried some ideas around in my head.

Please be aware that I might not have included every detail that you need to build this project. So I suggest that if you want to build it, carefully look things over and determine ahead of time if you have enough information to go forward.

It might be sufficient to simply guess at any needed information if you can't find it in the included files.

Please be aware that there might be mistakes in the documentation that I accounted for during the build but failed to note in the documentation.

Non-standard Dimensioning

My attitude toward dimensioning is to make it "good enough." Professional mechanical designers follow certain conventions regarding dimensioning. I'm not that careful. So understand this ahead of time when you find any dimensioning that is unconventional.

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The Baseball Equipment Cart Features

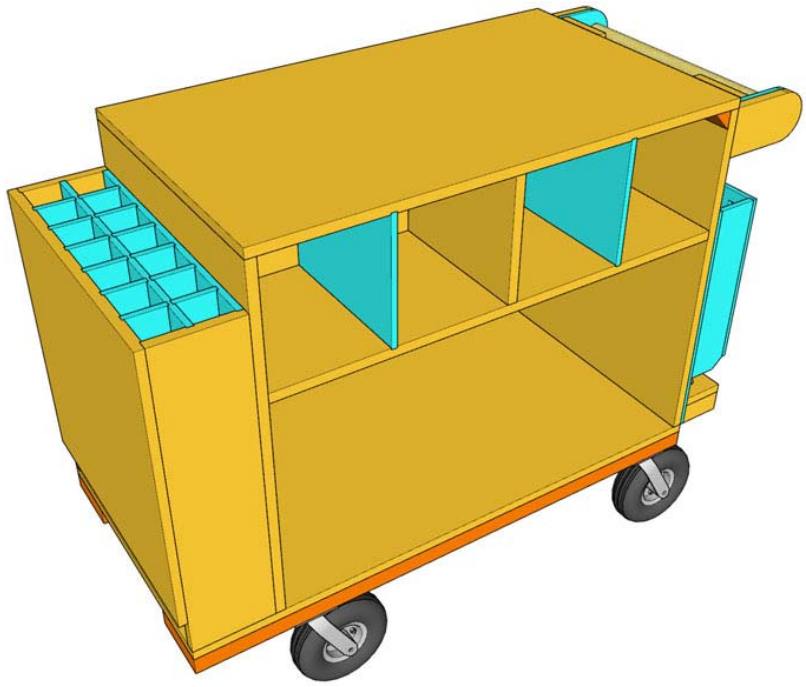

Figure 1. Overall View of the Cart

If you play or coach baseball, this cart can be a great help in easily transporting a lot of equipment from your pickup truck to the field on game day. Some of its features:

- A rack for 14 bats
- Dispensers for 24 baseballs
- Spaces for 4 helmets
- Room on the top for an equipment bag
- Room on the bottom for an ice chest and other items. (Move the ice chest to the top when you get to the field.)
- 8” (total height 9 1/2") pneumatic casters for smooth sailing over rough ground
- A comfortably large, 1 1/2” diameter handle to ease maneuvering of the cart
- You can use the top as a writing surface during the game
- Total height: 42 25/32"
- Total width: 23 1/2"
- Total length: 54 7/32"
- Height to center of handle: 39 7/16"
- Space for your hands in front of the handle: 2 1/2"
- Bat enclosure height: 26"
- Helmet Cavity Capacity: 9 1/4”W x 10”H x 12 3/4"D
- Size of the area below the helmets: 38 21/32”L x 23 1/2”W x 19”H
- Empty weight: about 150 lbs.

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SOME PRECAUTIONS

- **THIS CART IS NOT DESIGNED WITH BRAKES**
- **IT'S HEAVY EVEN WHEN IT'S EMPTY**
- **THINGS AND PEOPLE CAN FALL OFF ENDANGERING ANYONE NEARBY**
- **DO NOT ALLOW ANY PEOPLE OR ANIMALS TO RIDE IN OR ON THE CART, PARTICULARLY CHILDREN**
- **DO NOT ALLOW CHILDREN TO PUSH THE CART**
- **THE CART CAN EASILY ROLL DOWN A HILL OR INCLINE**
- **BE SURE TO BLOCK THE WHEELS SO IT WON'T ROLL WHEN YOU ARE NOT INTENTIONALLY PUSHING THE CART**
- **ENSURE THAT NO PERSON, ANIMAL, OR PROPERTY IS LOCATED WHERE THE CART MIGHT ROLL AND STRIKE THOSE THINGS**

Credit for the Design

The design was conceived by my son who, as a middle age adult, has a love for baseball and softball that has endured since he was 9 years old. He plays and coaches baseball and softball. Everyone in his family plays, too. So, as both a coach and a father, he has to transport a lot of equipment to his games. As the saying goes, "Necessity is the mother of invention." He conceived the features of the cart to ease his responsibility for so much equipment.

My task was merely to implement his concept. I'm responsible for all of the dimensioning, woodworking, and structural details.

The amount and sort of equipment that can be transported in the cart can be seen in Figure 2. Clearly, the cart can save a lot of labor.

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Figure 2. The Cart Loaded with Equipment

It should be noted that, aside from the Ball Dispensers (baseball, not softball) on the back, the cart is just as usable for softball as it is for baseball.

Some Important Information about the Plywood Used in This Build

I used marine exterior grade plywood for durability in an outdoor application. You can see the stamping on the edge of the plywood in Figure 3.

Figure 3. Marine Plywood Identification

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Two plywood thicknesses were used: 3/4” and 1/2”. As you may know, plywood is never the thickness that it’s rated for. For example, so-called 3/4” plywood is typically 23/32”. But the 3/4” plywood that I used in this design is different.

The 3/4” plywood I used was 51/64” thick, thicker than normal 3/4” plywood, and thicker even than 3/4”. YOU MIGHT HAVE TO MAKE SOME ADJUSTMENTS TO THE DIMENSIONS IN FILES *Equipment_Cart_10.skp* AND *Equipment_Cart_10.pdf* IF YOU YOUR PLYWOOD IS NOT 51/64” THICK.

The 1/2” plywood that I used in the project had a nominal thickness of 15/32”, which is typical for 1/2” plywood. The dimensions in the drawings assume 15/32”.

Loose Dado Dimensions

Best practice calls for dados to be cut to a width that makes a snug fit with the piece that will fit into each dado. I recommend that the dados for the 3/4” plywood that are cut into the Ball Back Ply, part of the Ball Dispensers, be cut for such a snug fit, which is 51/64” in the case of the plywood that I used. It might be different for your plywood.

On the other hand, there are a lot of dados needed for the 1/2” plywood. My 1/2” plywood was 15/32” thick. But I used a router with a 1/2” bit to cut the dados for all of my 15/32” plywood. I did this because several 1/2”pieces must be placed into several dados simultaneously. The extra slack was helpful in getting multiple 1/2” parts assembled at once. I encountered no issues with the build despite using such loose dados.

Casters

The cart uses 8” pneumatic casters. These enable relatively smooth travel over dirt, grass, and rough ground.

Fixed casters are used on the front. Swivel casters are used on the back. This configuration enables easy maneuvering of a heavy load. I purchased the casters at https://www.harborfreight.com/. Their part numbers are 42714 for the fixed casters (what they call rigid casters,) and 60251 for the swivel casters.

The caster base dimensions and hole pattern are shown in Figure 4. **Be sure to orient the hole pattern correctly when laying out the holes. It’s best to have the casers on hand to ensure the correct orientation.**

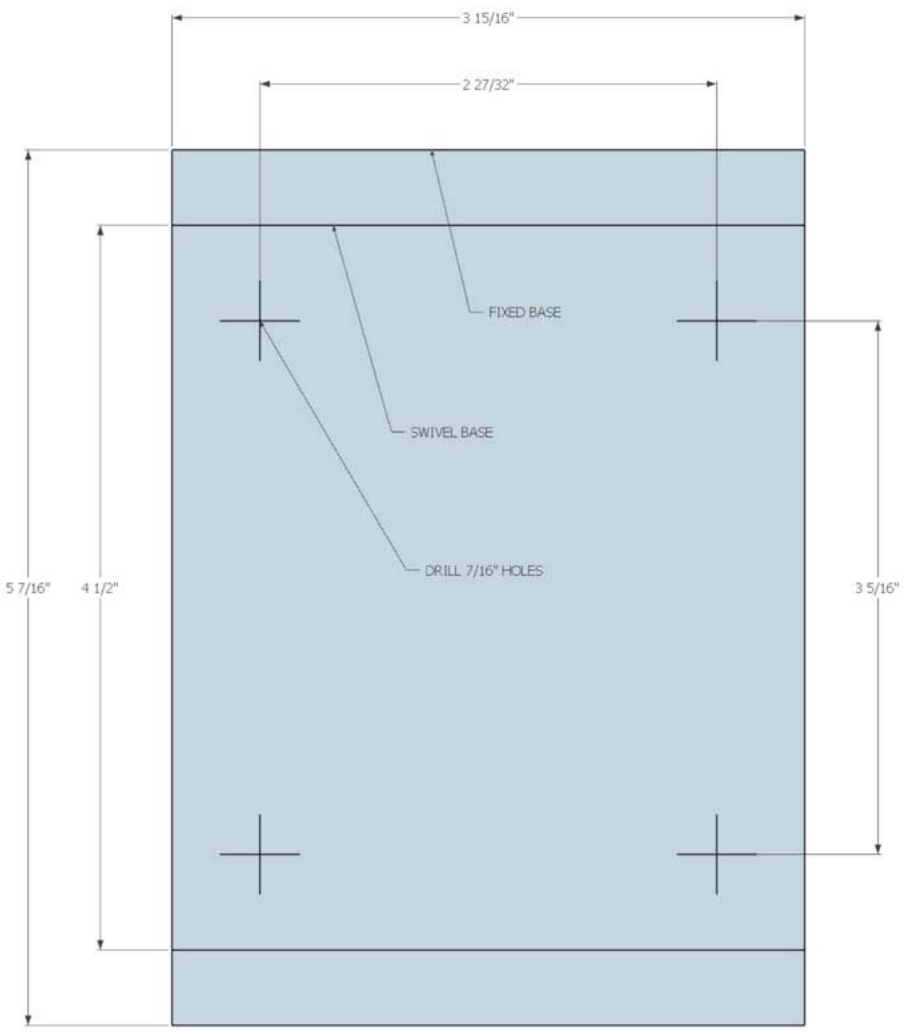

Figure 4. Caster Base Dimensions and Hole Pattern

Caster Mounting Hardware

The casters are held in place using 3/8” carriage bolts. **Note that the hardware used to mount the casters as well as the hardware used to mount two steel brackets are all made more secure by using *Loctite Threadlocker Blue* on the threads. This product is available at Lowe’s or Home Depot.**

Mounting the Front Fixed Casters

The front, fixed casters are mounted by running the bolts down through 7/16” holes in the Bottom Ply and Wheel Base, and then through the caster base. That is, the heads of the carriage bolts are located inside the cart, and the nuts, split washers, and flat washers, plus Loctite, are located outside the cart below the base of the caster. This is ideal since the heads of the bolts are smooth and won’t interfere with anything placed inside the cart.

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Mounting the Rear Swivel Casters

The rear, swivel casters don't have enough clearance for any hardware except the heads of the carriage bolts. For this reason, the bolts pass upward through the base of the swivel casters, through 7/16" holes in the Wheel Base and Bottom Ply, and are then held in place with flat washers, split washers, nuts, and Loctite. See Figure 5. This leaves relatively sharp or abrasive hardware exposed inside the cart where it might mar or damage anything placed inside the cart such as a plastic cooler or equipment bag.

Figure 5. Swivel Caster Hardware at Bottom of Cart

There are at least two ways to fix this problem: 1) grind off and smooth the ends of the bolts; 2) cover the hardware. You might want to use the first way. I chose the second way. See Figure 6.

Figure 6. Cover for Swivel Caster Hardware

You can see in Figure 6 that a plywood sandwich has been formed using a 3/4" piece on the bottom and a 1/2" piece on the top.

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A hand drawn sketch of the 3/4” bottom piece is shown in Figure 7.

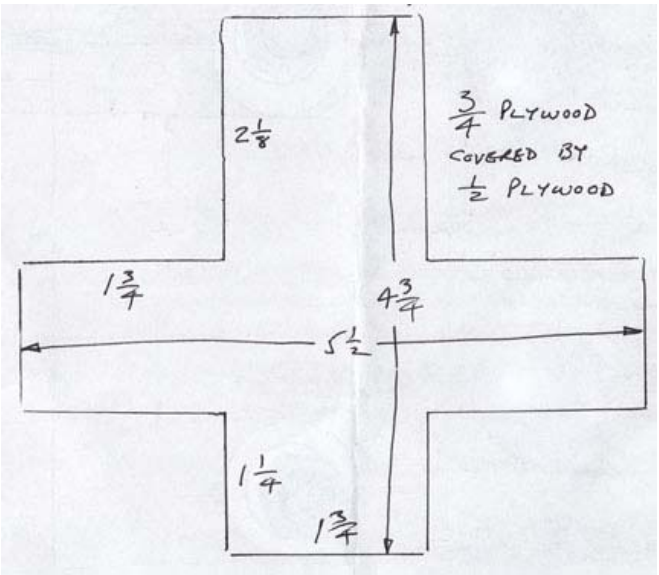

Figure 7. Swivel Caster Hardware Cover Bottom Piece

The bottom piece is glued onto the Bottom Ply. The top piece is screwed onto the bottom piece using countersunk screws **using no glue**. This permits removal of the top piece to get access to the hardware. The result is an effective, if odd looking, cover for the swivel caster hardware. The final assembly can be seen in Figure 8.

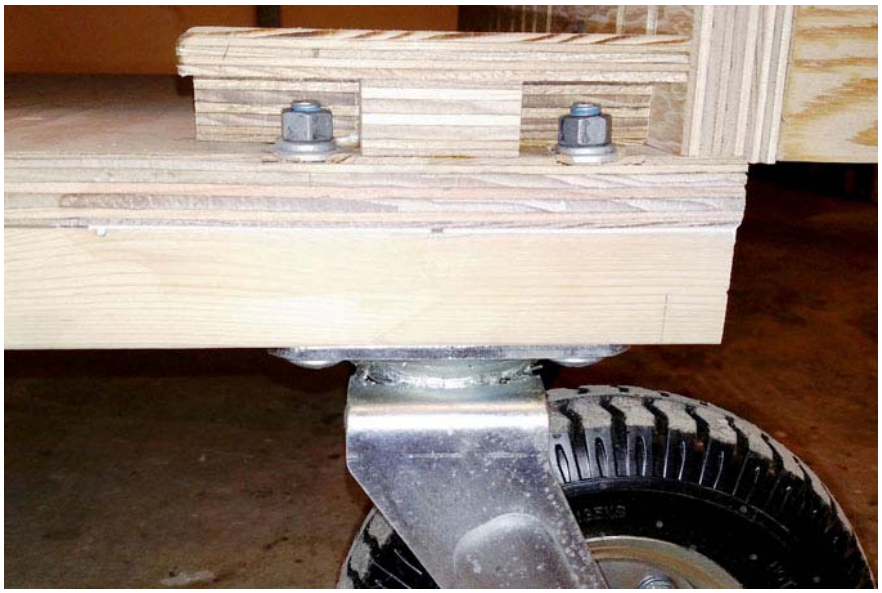

Figure 8. Side View Showing Swivel Caster Hardware Cover Over the Hardware

The top and bottom pieces of the swivel caster hardware covers are not part of the SketchUp/PDF file.

Racking

The cart has the potential to rack. It's basically a simple box with a top, bottom, front, and back. But without sides, there is little or no structure to resist distorting the cart when pushing on the handle. This phenomenon is illustrated in Figure 9.

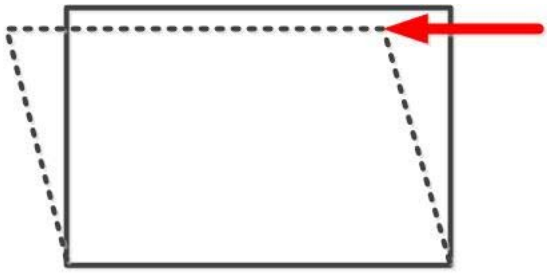

Figure 9. Racking: The Cart Tends to Distort When a Force Is Applied to One Corner

Some of the structure of the cart resists racking. First, heavy duty metal brackets are mounted at the bottom of the cart at the junction between the Bottom Ply and Back Ply. The 2 1/2" wide, 7-gauge galvanized steel brackets are shown in Figure 10. They're part number HL53 available from https://www.fastenersplus.com/Simpson-HL53-5x3-Heavy-Angle-G90-Galvanized.

Figure 10. Heavy-duty 7-gauge Brackets

The brackets are shown in Figure 11 mounted to the bottom rear of the cart with 1/2" carriage bolts.

Figure 11. Brackets Mounted to Bottom Rear of Cart with 1/2" Carriage Bolts

Figure 12 shows the brackets during the initial construction. Here you see the Back Ply sitting on the Bottom Ply with the brackets linking the two pieces. **Because the radius of the bend on the inside of the brackets is slightly rounded, you should file off the sharp edges of the plywood where the brackets wrap around it so that the flats of the brackets fit flush against the Bottom Ply and Back Ply.**

Figure 12. Brackets Attached Before Other Parts of the Construction

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You can see in Figure 12 that the brackets are attached early in the build. **Information about locating the brackets is given on Page 30.**

As noted on Page 11, hardware used to mount the brackets as well as the hardware used to mount the casters are all made more secure by using *Loctite Threadlocker Blue* on the threads.

Second, several other components that resist racking are shown in Figure 13.

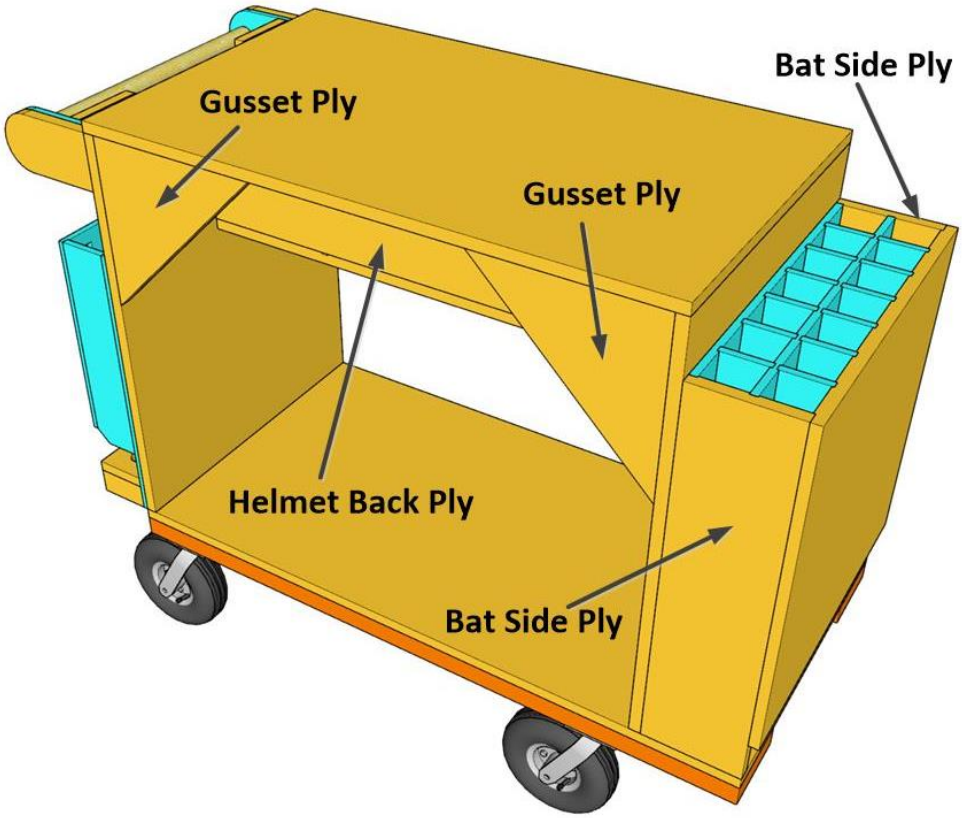

Figure 13. Rack-resisting Components

Glue

Glue is used everywhere it makes sense to use it. I used Titebond III, a waterproof glue, since the cart will be used outside where it can get wet from rain, wet grass, puddles, and sprinklers. Any equivalent waterproof glue is probably acceptable.

Finish

I elected to use no finish. I left it to the end-user to apply whatever finish he wanted. It's a utilitarian cart made from marine exterior plywood, so it's fairly weather resistant. But it should probably have a finish applied to better protect it from the weather.

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Fabrication Details

Follow the SketchUp File or the Equivalent PDF File

File *Equipment_Cart_10.skp* is the SketchUp design for the stool. This file is useful since nearly all of the necessary details are incorporated here. So, for example, if you find a dimension or other detail missing, it can be determined by examining this file. And, you can orbit and move the model around for a better look at everything.

File *Equipment_Cart_10.pdf* contains all of the images and dimensions from the SketchUp file. Use this if you're not familiar with SketchUp.

USE THESE FILES TO FOLLOW ALONG WITH THE INFORMATION PROVIDED BELOW. WITH A FEW EXCEPTIONS, EACH HEADING REFERS TO A PARTICULAR PAGE IN THE FILES.

Colors Used in the Files

Yellow/Dark Yellow: All of the 3/4" plywood (that is, 51/64" actual dimension in my build) is yellow or dark yellow. Unfortunately, the shade of the yellow varies as the viewing angle in changed.

Cyan: All of the 1/2" plywood (that is, 15/32" actual dimension in my build) is cyan.

Orange: All of the solid wood (non-plywood) pieces, except the handle, are orange. This material can be spruce or Douglas fir.

Other color: The handle can be made with whatever material you find available. I think I used pine. While a texture was applied to the handle in the files, no specific color was intended.

Overview

This view shows the general appearance and construction of the cart:

- The Bat Rack is at the front
- Cavities for 4 helmets are located under the top on one side. To be clear, two of the partitions are 1/2" plywood (cyan) and one is 3/4" plywood (yellow/dark yellow)
- A pair of 2x6 solid wood boards (orange) run below the bottom of the cart to support the casters and give the cart strength
- An 8" pneumatic caster is placed near each corner with fixed casters used at the front and swivel casters used at the back. (They all look the same in the drawing. This was done for convenience.)
- Part of one Baseball Dispenser can be seen at the back
- Part of the Handle Assembly can be seen at the back

Overview Callouts

This is the same view as the Overview page but with the names assigned to all of the pieces visible in this view.

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Notice the Small Gusset, a small piece (orange) just below the Top Ply in the last helmet cavity. It's glued into place to strengthen the joint between the Top Ply and Back Ply plywood. A lot of stress can be applied when pushing or pulling the handle so that the joint where the Top Ply and Back Ply meet was reinforced using this piece.

Reverse View

Two large Gussets and the Helmet Back Ply can be seen in this view. The Gussets were included to resist the racking described on Page 14.

Back View

You can see all of the Ball Dispensers. Each holds up to 6 baseballs for a total capacity of 24.

Also seen in this view is the Handle Assembly. It comprises a 1 1/2" dowel and layers of both 3/4" plywood (yellow/dark yellow) and 1/2" plywood (cyan.)

The dimensioning given for the placement of the Ball Dispensers is important because the heavy gauge steel brackets are placed between the outer dispensers and the inner dispensers. (See Figure 11 in this document and the Steel Bracket Location page in the SketchUp/PDF file.) So room is needed for the brackets.

Front View

The Bat Rack occupies the entire front of the cart. You can see the bottom portion of the inner rack assembly through the built-in 3" slot. The slot provides easy access to the bottom of the assembly for removing dirt and debris. It also allows access to shorter items such as children's bats.

Ball Dispenser

The box portion of the Ball Dispensers is made with 1/2" plywood. The base is made with 3/4" plywood for strength. You can fill each dispenser with up to 6 baseballs. The bottom ball is held in place by the round hole in the base and a **1/4" chamfer around the hole that is not shown**.

The slots at the front allow you to see how many balls remain. It was necessary break the slots into two parts so that the bridge at the center would help to maintain the strength of the dispenser. Notice that the slots are drawn as rectangular, but I cut mine using a router which caused the slots to be round at the ends.

Simply load up a dispenser with up to 6 balls. When a ball is needed during a game, just slide one out from the bottom and the rest will fall into place.

A Caution about the Ball Dispenser

When rolling the cart over rough ground with baseballs in the Ball Dispenser, the bouncing and rocking of the cart can dislodge the bottom balls and allow them to fall onto the ground. One solution is to wait until game time before putting the balls in the dispensers.

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Another solution is to **perhaps add a rubber or leather flap over the front opening at the bottom**. This could keep the balls in place when the cart is bouncing over rough ground and still allow easy access during a game.

Ball Dispenser Dimensions

The pieces of the Ball Dispenser are aligned using rabbets and a dado. Rabbets in the front and back ensure that the sides are aligned with them.

Notice that the rabbets near the bottom of the back are wider than the rabbets above them. The rabbets toward the top accommodate the 1/2” (15/32”) thick sides. The rabbets at the bottom accommodate the 3/4” (51/64”) thick parts of the base.

The dado near the bottom accommodates the 3/4” (51/64”) thick base. **All rabbets and dado are 1/8” deep.**

You’ll have to make appropriate changes to your fabrication if your plywood thickness is different than what the drawings call for.

Ball Dispenser Assembly

Screws were used in addition to glue. The figures that appear next show how the screws are arranged.

Figure 14. Screws on the Front of the Ball Dispenser

Figure 15. Screws on the Back of the Ball Dispenser

Figure 16. Screws into the Back of the Ball Dispenser Base

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Figure 17. Screws into the Base of the Ball Dispenser

Notice the 1/4”-wide chamfer around the 1 1/2” hole in Figure 17. The chamfer is not shown in the SketchUp/PDF drawing. It enhances the ability to hold the bottom ball in the dispenser while still permitting easy removal of a ball at game time.

Bat Rack Overview

The Bat Rack accommodates 14 bats. That is, it accommodates baseball bats with barrels up to the largest major league regulation diameter. Of course, because softball bats are narrower than baseball bats, the Bat Rack can accommodate those, too.

The front and sides are 3/4” plywood. The matrix inside is 1/2” plywood.

The front piece (Bat Front Ply) is designed to allow for a 3” space beneath it. The space gives access to any dirt or debris that might fall inside. Also, if a shorter child’s bat is placed in the Bat Rack, it can be seen at the bottom.

Notice the rabbets and dados in the front, sides, back, and the plywood running down the center. These ensure the alignment of all of the pieces during glue-up and assembly. And, they keep all pieces locked into place during the rough treatment that you can expect during a game while removing and inserting bats.

An example of a Bat Rack assembly can be seen in Figure 18.

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Figure 18. Bat Rack Assembly – Note the Rabbets and Dados

Attaching the Bat Rack to the Cart

The Bat Rack rests on the Bottom Ply, against the Front Ply. It's glued into place and secured with screws. You can see the screws in Figure 19 as they run along the edge of the Front Ply where they penetrate through the Front Ply and into the edges of the Bat Rack.

Similar screws that aren't seen in the picture pass through the Bottom Ply into the edges of the Bat Rack. **Of course, these screws must be installed before the Wheel Bases pieces are attached.**

Figure 19. Attaching Hardware

Special Considerations When Using the Bat Rack

Bats are going to *crash* against the Bottom Ply when they're dropped into the Bat Rack. The impact of the roughly 2-pound bats landing against the hard surface of the Bottom Ply will cause a lot of shock and stress. It will be like hitting the Bottom Ply with a hammer. I suggest that you **install a heavy foam pad, maybe 1" thick, at the bottom of the Bat Rack through the 3" gap to protect the Bottom Ply.**

Another problem can be caused when removing bats from the Bat Rack. Players are going to be thinking about the game and they'll be in a hurry. So it's inevitable that they'll pull a bat away from the Bat Rack before it's fully cleared the rack. The result is that the bat will act like a crowbar against the rack and possibly stress it enough to break it. **The answer is to be careful: Always remove a bat from the Bat Rack completely before pulling the bat to the front or side.**

Bat Rack Dimensions

This drawing is thorough. The dimensions should provide enough information to fabricate the Bat Rack. **Though not visible in the drawing, the Bat Center Ply is the same height as the Bat Front Ply: 23".**

All of the pieces are glued together. Because the dados in the Bat Center Ply oppose each other in pairs, the ability to reinforce the structure with screws is difficult. Two columns of 5 screws each were added to both the Bat Back Ply and Bat Center Ply. #6x1" screws are used on the center two Bat Plies. The

screws are arranged 2" from either end and spaced 4-3/4" in between. This arrangement isn't perfect but it's better than using no screws in the Bat Rack.

Figure 20. #6x1" Screws in Center Two Dados of Bat Center Ply

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Figure 21. #6x1" Screws Through Back of Center Two Dados of Bat Back Ply

Handle Assembly

The Handle Assembly was designed to be simple but strong since a lot of force will be acting on the handle. Two stacks of three 3/4” plywood pieces (the Handle Ply) are glued and stacked together. A 3/4” Handle Brace Alt[1] Ply is glued to a 1/2” Handle Brace Thin Ply.

The Handle Brace Thin Ply has a 1 1/2” diameter hole drilled into it to accommodate the 1 1/2” dowel. The Handle Brace Thin Ply captures the dowel handle and the Handle Brace Alt Ply limits the side-to-side movement of the dowel handle. The Hand Brace Thin Ply and Handle Brace Alt Ply are glued together and, in turn, glued to the Handle Ply stack.

The Handle Assembly mounts to the Back Ply where it’s glued and screwed into place. Notice in the Back View drawing that **the top of the Handle Assembly is aligned with the top of the Back Ply, not the top of the Top Ply.**

[1] There is no significance to the “Alt” term. It simply refers to a name given to a new version of an old part as the design drawing progressed. The original, non-“Alt” version of the part was deleted.

Handle Mounting

These are two plan views that show the screw patterns for the Handle Assembly. I used #9x2 1/2" screws to mount and secure the Handle Assembly.

The view at the left shows the screw pattern from <u>inside the Back Ply</u>. That is, the end of the Handle Assembly mounts against the Back Ply and the screws penetrate through the Back Ply and into the assembly. Since the screws are 2 1/2" long and the Back Ply is nominally 3/4" thick, the screws penetrate about 1 3/4" into the Handle Assembly.

Note that the 6 17/64" dimension is approximate and will depend on the actual thickness of your plywood. For the purpose of laying out the screw pattern inside the Back Ply, consider it simply to be 6 1/4".

The view at the right shows the pattern of the screws from the outside of the end of the assembly. Again, 2 1/2" screws are used. They penetrate through the Handle Brace Alt Ply and into the rest of the assembly for a total penetration of 2 1/2". The x-ray view in Figure 22 should convince you that the screws don't interfere with each other. But it should also be clear that **the screws should be placed carefully so that a drill bit or screw will not hit another screw.**

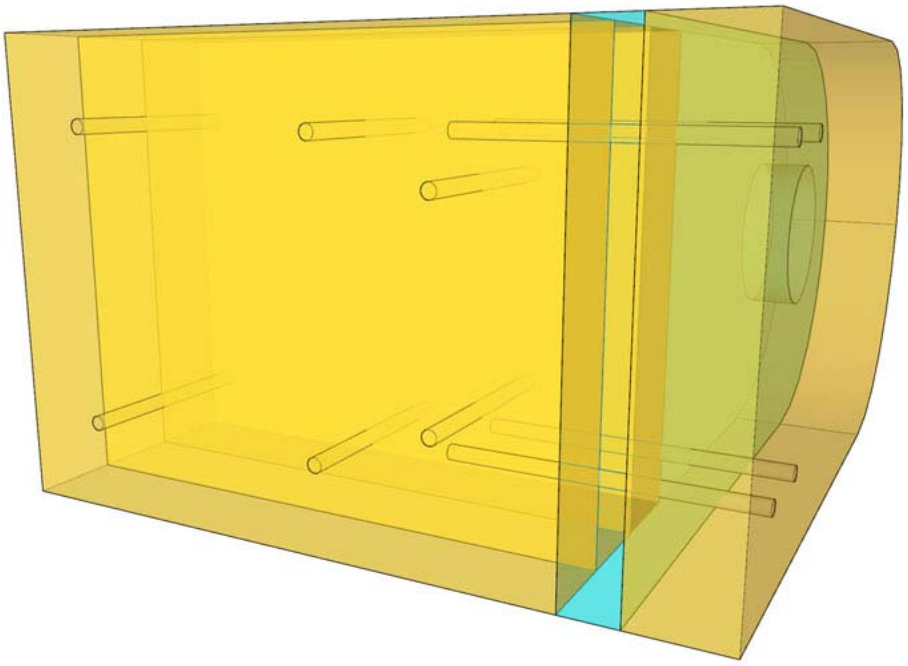

Figure 22. X-ray View of Screw Penetrations in Handle Assembly

Handle Dimensions

As seen in other views, 3 Handle Ply pieces are glued together to make a single block. Two such blocks are used. **It can be difficult to align pieces like these when doing glue-ups. So you might want to cut the pieces a little oversize and glue them together with adequate clamping. Trim them to their final dimensions after the glue has cured and the clamps have been removed.**

Also as seen in other views, a Handle Brace Alt Ply is glued together with a Hand Brace Thin Ply. Two such assemblies are needed. Be careful when gluing these pieces that glue squeeze-out does not fill in any portion of the hole in the Hand Brace Thin Ply; otherwise, the hardened glue will interfere with seating the handle.

Handle Length Considerations

The length of the handle in the drawing is given as 21 27/32”. This allows 1/16” of margin with the *design* dimension of 21 29/32” between the surfaces of the two Handle Brace Alt Ply pieces. Differences in plywood thickness or differences between your actual build dimensions and the design dimension mean that **you should select the length for your handle based on your actual dimensions, not the dimension in this drawing.** Be sure to allow about 1/16” extra space for the length of the handle to avoid interference when seating it in the end assemblies.

Use Dowels to Secure the Handle

I used a 1/2” dowel through each end of the Handle Assembly to secure the dowel. **The dowels are not shown in the SketchUp/PDF drawings.** See Figure 23.

Figure 23. Dowels Used to Secure the Handle

Helmet Rack

This drawing is very busy with a lot of detail. Notice that the 1/2” Helmet Ply are captured in dados, both in the Helmet Bottom Ply and in the Top Ply (not shown in this view), but **the 3/4” Helmet Thick Ply is *not* captured in dados**.

Each 1/2” Helmet Ply is simply glued into its dados. No screws are used.

Custom Fit the Helmet Back Ply

The Helmet Back Ply is shown with a dimension of 38 1/2". This is the ideal *design* length. **But it's imperative that the Helmet Back Ply fit between the Front Ply and Back Ply *exactly*. This is because the Helmet Back Ply is a key component in resisting the racking of the cart. Notice its location in Figure 13. Therefore, the length of the Helmet Back Ply must be custom cut to fit in its location *exactly*.**

Securing the Helmet Rack into the Cart

The 3/4" Helmet Thick Ply is held in place with screws through the Helmet Bottom Ply and through the Helmet Back Ply. It's secured to the bottom of the Top Ply using pocket screws in pocket holes cut along the top edge of the Helmet Thick Ply.

The Helmet Back Ply is joined to the cart's Top Ply using multiple pocket screws. It's also joined to the Back Ply and Front Ply using pocket screws. All of the pockets are cut into the reverse side of the Helmet Back Ply.

The Helmet Bottom Ply is joined to the Helmet Back Ply using multiple screws driven in through the bottom of the Helmet Bottom Ply and directly into the bottom edge of the Helmet Back Ply. The Helmet Bottom Ply is joined to the cart's Front Ply and Back Ply using multiple pocket screws with the pockets cut into the bottom of the Helmet Bottom Ply.

This method of joining the Helmet Rack to the cart enhances the cart's ability to resist racking.

Carrying Helmets in the Helmet Rack

The helmet cavities formed by the helmet rack are adequately sized to hold most baseball helmets. That is, the helmets will fit just fine. **But the helmets can fall out of the cavities when the cart is rolled along rough or uneven ground. This is the reason for the bungee cords that you can see strung in front of the helmets in Figure 2.**

You will probably have to address the problem of helmets falling out of their storage areas. One solution is the use of carefully placed bungee cords. **One other approach might be to add a shallow wooden lip along the front edge of each helmet cavity that will interfere with the helmet sliding out of the cart, but not prevent the helmet from being removed when needed.** Maybe you'll think of a better method.

Gusset

The two Gussets can be seen in Figure 2 and the Reverse View drawing. They were included in the design to help the cart resist racking. They're held in place using multiple pocket screws on the inside located along the edges that meet the Top Ply and Back Ply, and the Top Ply and Front Ply. The Gussets must have a good, uniform, tight fit since they're structural.

Small Gusset

The Small Gusset is a piece of spruce or Douglas fir glued into the corner of the rear-most helmet cavity where the Top Ply meets the Back Ply. As described earlier on Page 18, a lot of stress can be applied

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when pushing or pulling the handle. So the joint where the Top Ply and Back Ply meet was reinforced using this piece. It's simply glued into place; no screws are used.

Note that the end of the Small Gusset is flush with the outside edges of the Back Ply and Top Ply. It's 12 1/2" long, 1/4" shorter than the depth of the helmet cavities so that it should seat easily into position.

Front Back

The Front Ply and Back Ply are identical pieces of 3/4" plywood. Each is joined to the Top Ply and Bottom Ply using multiple pocket screws with the pockets cut along the top and bottom edges of the Front Ply and Back Ply pieces.

The top and bottom edges of the Front Ply each have 14 evenly spaced pocket screws to attach it to the Top Ply and Bottom Ply. Refer to Figure 19 to see how the pocket holes are arranged.

The top edge of the Back Ply has 14 evenly spaced pocket screws to attach it to the Top Ply. <u>But the bottom of the Back Ply is different.</u>

The bottom of the Back Ply uses only 10 pocket screws to join it to the Bottom Ply. It uses 4 fewer screws because 2 pocket screws are not used in the area where each of the 2 brackets is attached. If you look at Figure 5 you can see that there are no pocket screws immediately adjacent to the heads of the carriage bolts.

Top

The most striking features of this piece are the two 1/8" deep dados. These are used to align the two 1/2" thick Helmet Ply components. The dados are best cut using a router. There is no need to square the ends of the dados. Simply leave them round.

Bottom

The Bottom Ply is the biggest piece of plywood used in the project. Be sure to cut the edges square.

Wheel Base

The two Wheel Base pieces give the cart strength and rigidity. These 2x6 pieces (1 1/2" x 5 1/2" actual size) can be spruce or Douglas fir.

It's very important for the Wheel Base pieces to be as straight, not warped, not cupped, and not twisted as possible. They are bolted to the Bottom Ply with screws and four 3/8" bolts at each caster. This means that they will be tightly joined very tightly with the Bottom Ply. **(Don't use glue to attach the Wheel Bases to the Bottom Ply.** If they should rot later, they'll be easier to replace if they aren't glued.)

Any warping, cupping, or twisting in either Wheel Base piece will be reflected in the contours of the Bottom Ply and will affect the overall squareness of the cart. **In fact, bolting the straight Bottom Ply plywood to a distorted Wheel Base could cause the plywood to crack. This, obviously, should be avoided.**

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Look at Figure 19 to see the pattern of screws through the Bottom Ply and into the Wheel Base pieces.

Be sure that the cut-outs in the Wheel Base pieces are oriented toward the center of the Bottom Ply when you attach them to the cart.

Steel Bracket Location

This drawing shows where to locate the centers of the 1/2” bracket bolts. Use 9/16” holes centered 5 1/2” from each edge of the Back Ply and Bottom Ply.

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Cutting Diagrams

All of the diagrams in this section were generated by the Cut List 4.1 SketchUp extension, version 4.1.12. They are the cutting suggestions that the extension generated. You might come up with a more efficient method for cutting your material. **Note that the Handle Alt dowel is not included here since it isn't made from either boards or plywood.**

Solid Boards

Figure 24 is the cutting diagram for the Douglas fir or spruce material. It shows that a minimum of 2 boards of 2x6x96 (1 1/2" x 5 1/2" x 96") are needed. However, **if your lumberyard offers 12-foot 2x6 boards, then all of the material can be cut from just one 12' board.** That is, each Wheel Base is 46 21/32" long, so if you cut the 12' board in half such that each has a length of 72", then you will have enough material in each board for one Wheel Base with enough left over to make the 12 1/2" Small Gusset. A 10' board might work, too, but with very little margin.

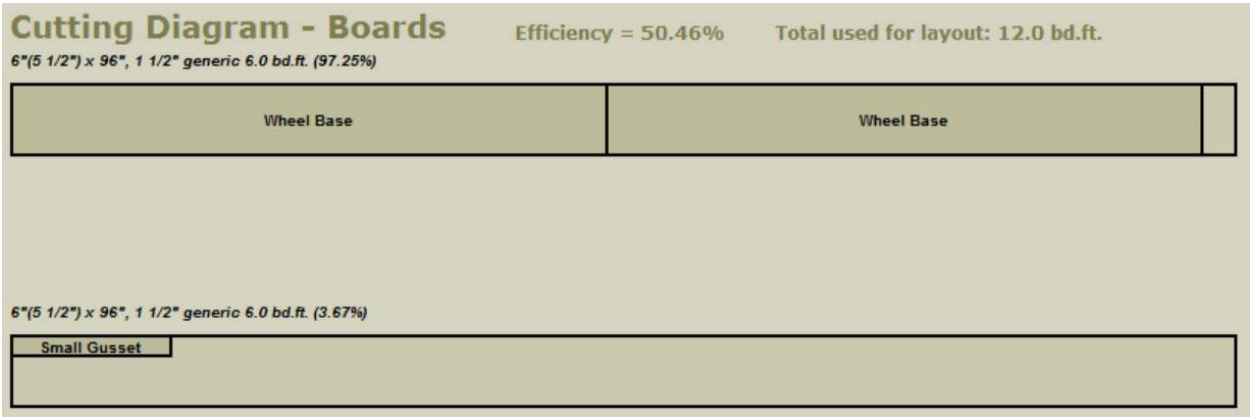

Figure 24. Solid Board Cutting Diagram

Plywood

The cutting diagrams will show that you will need **one 48x96 sheet of 1/2" plywood** and **two 48x96 sheets of 3/4" plywood**. It's recommended that you use marine exterior grade plywood.

1/2" Plywood

Figure 25 shows that about 71% of the sheet is used.

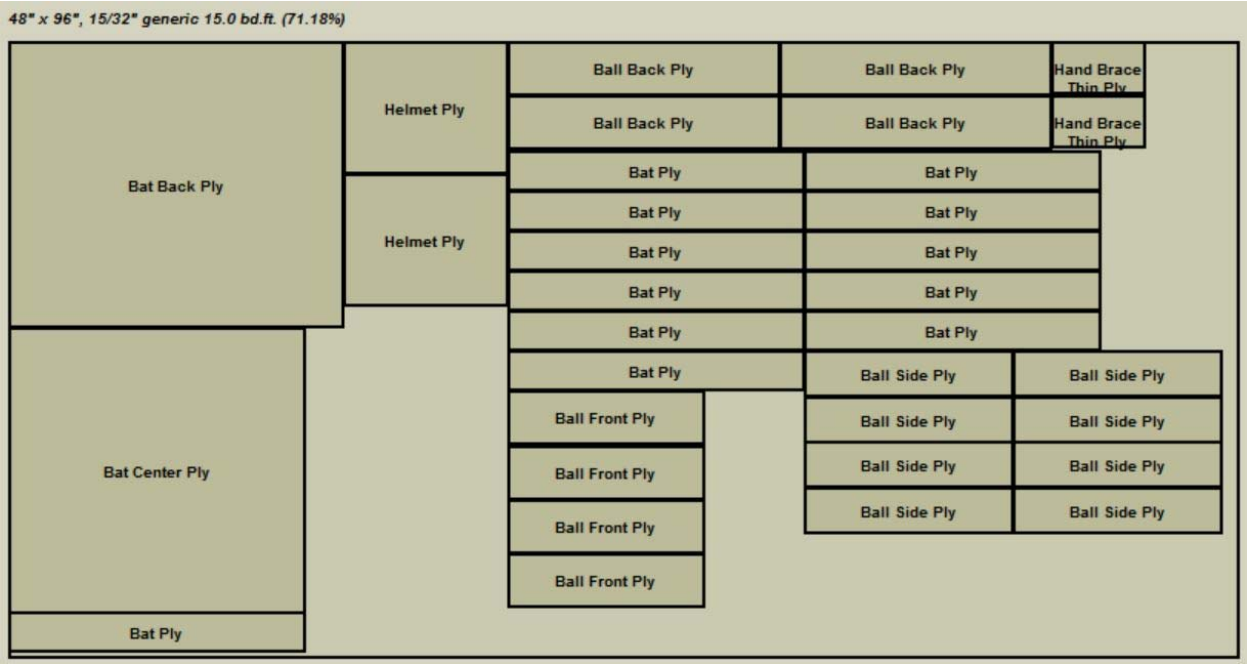

Figure 25. 1/2" Plywood Cutting Diagram

3/4” Plywood

Figure 26 shows the two sheets of 3/4” plywood are needed. The first sheet is more than 87% used. The second sheet is almost 42% used.

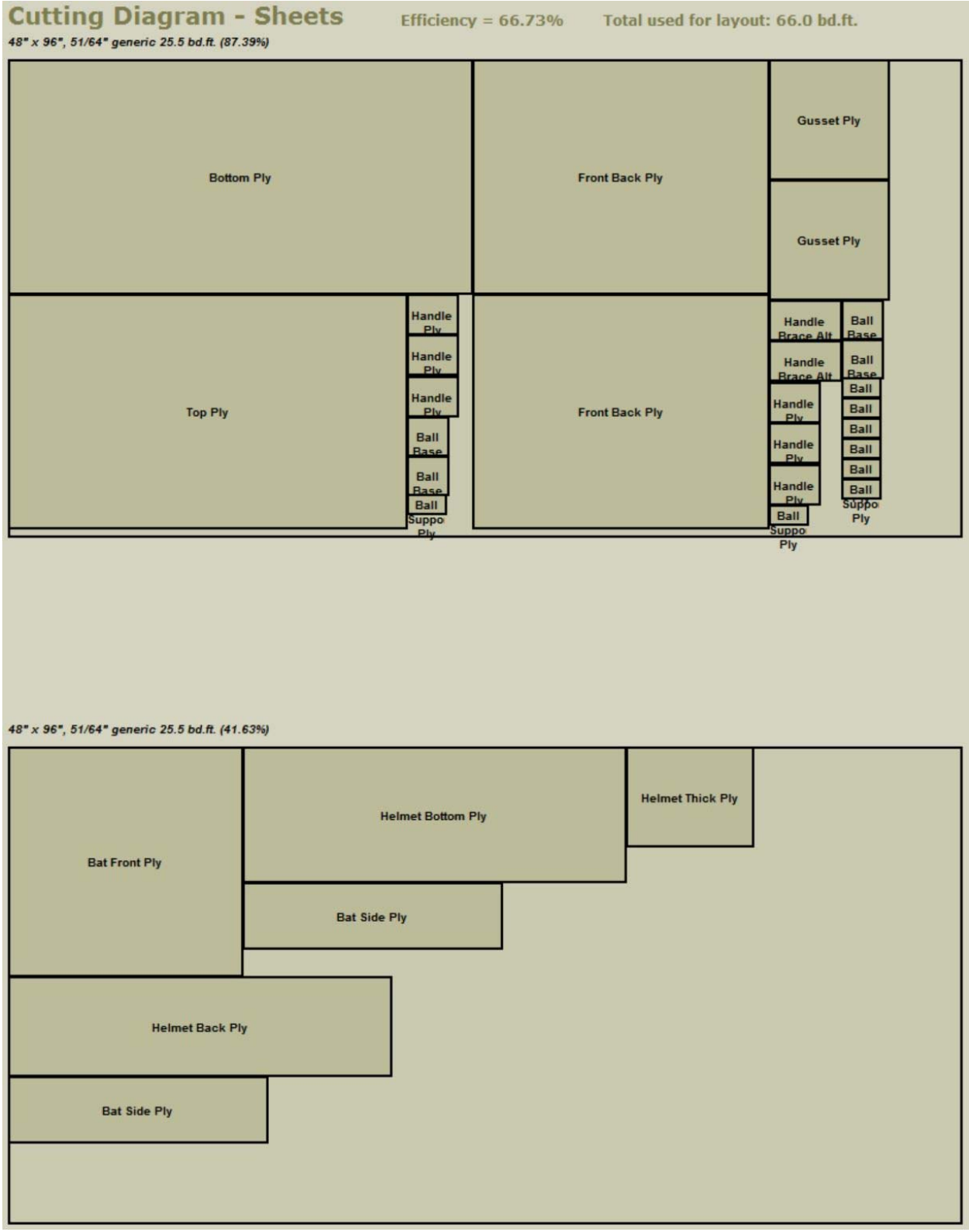

Figure 26. 3/4" Plywood Cutting Diagrams

Cut Lists

Cut List Generated by the Cut List 4.1 SketchUp Extension

Figure 27 is the cut list generated by the Cut List 4.1 SketchUp extension, version 4.1.12. It provides all of the plywood cutting dimensions. (The cut list for the solid wood was not included here.) Unfortunately, the 1/2” material and 3/4” material are mixed together. Nevertheless, the list is very useful in the shop when cutting all of the material for the cart. **However, an improved version of the table is available below.**

Sheet Goods

Part#	Quantity	Description	Length (L)	Width (W)	Thickness (T)	Square Foot (per)	Square Foot (total)	Total Length (Feet)	Material
S-001	4	Ball Back Ply	21 3/32"	4 1/8"	15/32"	0.6	2.4	7.04	[Color H04]
S-002	4	Ball Base Ply	4 1/8"	3 25/32"	51/64"	0.11	0.44	1.36	[Color D04]
S-003	4	Ball Front Ply	15 3/16"	4 1/8"	15/32"	0.44	1.76	5.08	[Color H04]
S-004	8	Ball Side Ply	16 3/16"	3 7/16"	15/32"	0.39	3.12	10.8	[Color H04]
S-005	8	Ball Support Ply	3 25/32"	1 59/64"	51/64"	0.05	0.4	2.56	[Color D04]
S-006	1	Bat Back Ply	26"	22 5/32"	15/32"	4.0	4.0	2.17	[Color H04]
S-007	1	Bat Center Ply	23"	22 5/32"	15/32"	3.54	3.54	1.92	[Color H04]
S-008	1	Bat Front Ply	23 1/2"	23"	51/64"	3.75	3.75	1.96	[Color D04]
S-009	12	Bat Ply	23"	3"	15/32"	0.48	5.76	23.04	[Color H04]
S-010	2	Bat Side Ply	26"	6 9/16"	51/64"	1.18	2.36	4.34	[Color D04]
S-011	1	Bottom Ply	46 21/32"	23 1/2"	51/64"	7.61	7.61	3.89	[0056_Yellow]
S-012	2	Front Back Ply	29 23/32"	23 1/2"	51/64"	4.85	9.7	4.96	[Color D04]
S-013	2	Gusset Ply	12"	12"	51/64"	1.0	2.0	2.0	[Color D04]
S-014	2	Hand Brace Thin Ply	7 1/4"	4"	15/32"	0.2	0.4	1.2	[Color H04]
S-015	2	Handle Brace Alt Ply	7 1/4"	4"	51/64"	0.2	0.4	1.2	[Color D04]
S-016	6	Handle Ply	5"	4"	51/64"	0.14	0.84	2.52	[Color D04]
S-017	1	Helmet Back Ply	38 1/2"	10"	51/64"	2.67	2.67	3.21	[Color D04]
S-018	1	Helmet Bottom Ply	38 1/2"	13 35/64"	51/64"	3.62	3.62	3.21	[Color D04]
S-019	2	Helmet Ply	12 3/4"	10 1/4"	15/32"	0.91	1.82	2.12	[Color H04]
S-020	1	Helmet Thick Ply	12 3/4"	10"	51/64"	0.89	0.89	1.06	[Color D04]
S-021	1	Top Ply	40 3/32"	23 1/2"	51/64"	6.54	6.54	3.34	[Color D04]

Figure 27. Original Cut List Generated by the Cut List 4.1 SketchUp Extension

Matched and Cross-Labeled Cut List Dimensions

Figure 28 is an improved version of Figure 27. First, notice that it’s simpler. Second, it also includes the solid board material. Finally, and most importantly, **it’s labeled so that you can identify all of the cuts having the same dimension.** This can enable you—where possible—to use the same tooling setup to cut all parts that have the same dimension; thus, all cuts with the same dimension can be cut to *exactly* the same size.

The table in Figure 27 contains 10 columns. The table in Figure 28 contains 8 columns. **But look again at the 5th and 6th columns in Figure 28. They’re the only columns without headings.** They contain the labels A, B, C, etc. **Every item labeled with an A has the same dimension as every other item labeled with an A. Similarly, all items labeled with a B have the same dimension, as do the items labeled with C, D, and so on. Items with unique dimensions don’t have labels.**

Use the labels as a guide as you cut your material.

```
************************************************************************
**************  MATCHED AND CROSS-LABELED CUTLIST DIMENSIONS  ************
************************************************************************

FILE: Equipment_Cart_10_CutList_MATCHED.txt

Part# Quantity Description            Length(L)        Width(W)   Thick(T)
C-001 1        Small Gusset           12 1/2"          1 1/2"     1 1/2"
C-002 2        Wheel Base             46 21/32"  A     5 1/2"     1 1/2"
S-001 4        Ball Back Ply          21 3/32"      B  4 1/8"     15/32"
S-002 4        Ball Base Ply          4 1/8"     B  C  3 25/32"   51/64"
S-003 4        Ball Front Ply         15 3/16"      B  4 1/8"     15/32"
S-004 8        Ball Side Ply          16 3/16"         3 7/16"    15/32"
S-005 8        Ball Support Ply       3 25/32"   C     1 59/64"   51/64"
S-006 1        Bat Back Ply           26"        D  L  22 5/32"   15/32"
S-007 1        Bat Center Ply         23"        E  L  22 5/32"   15/32"
S-008 1        Bat Front Ply          23 1/2"    F  E  23"        51/64"
S-009 12       Bat Ply                23"        E     3"         15/32"
S-010 2        Bat Side Ply           26"        D     6 9/16"    51/64"
S-011 1        Bottom Ply             46 21/32"  A  F  23 1/2"    51/64"
S-012 2        Front Back Ply         29 23/32"     F  23 1/2"    51/64"
S-013 2        Gusset Ply             12"        G  G  12"        51/64"
S-014 2        Hand Brace Thin Ply    7 1/4"     H  M  4"         15/32"
S-015 2        Handle Brace Alt Ply   7 1/4"     H  M  4"         51/64"
S-016 6        Handle Ply             5"            M  4"         51/64"
S-017 1        Helmet Back Ply        38 1/2"    J  N  10"        51/64"
S-018 1        Helmet Bottom Ply      38 1/2"    J     13 35/64"  51/64"
S-019 2        Helmet Ply             12 3/4"    K     10 1/4"    15/32"
S-020 1        Helmet Thick Ply       12 3/4"    K  N  10"        51/64"
S-021 1        Top Ply                40 3/32"      F  23 1/2"    51/64"
```

Figure 28. Matched and Cross-Labeled Cut List

If you like what you see in Figure 28, and if you use SketchUp with the Cut List 4.1 extension, you can create your own matched and cross-labeled cut list tables for your SketchUp projects. Just download and run the CutlistCSV app, *CutlistCSV_Ver_1.4_64_Bits.zip*, from https://bobpenoyer.com/sketchup_sup.htm. The link to the free download is available near the middle of the page. All of the instructions for its use are provided on that page.

The Cut List 4.1 Setup

If you're interested, the following images show how the Cut List extension was set up to gather the data presented in Figure 24 through Figure 28.

The opening window is shown in Figure 29. Note two things about this window. First, the CSV box is checked. This is necessary to create the file used by the CutlistCSV app. If you choose not to use this app, you can decide if you want to generate a comma-separated variables file. If not, leave the box unchecked.

Second, the word “ply” has been added to the list in the *Sheet Material Words* list. With “ply” in the list, appending “ply” or “Ply” to a component name tells Cut List 4.1 that a components is made with plywood.

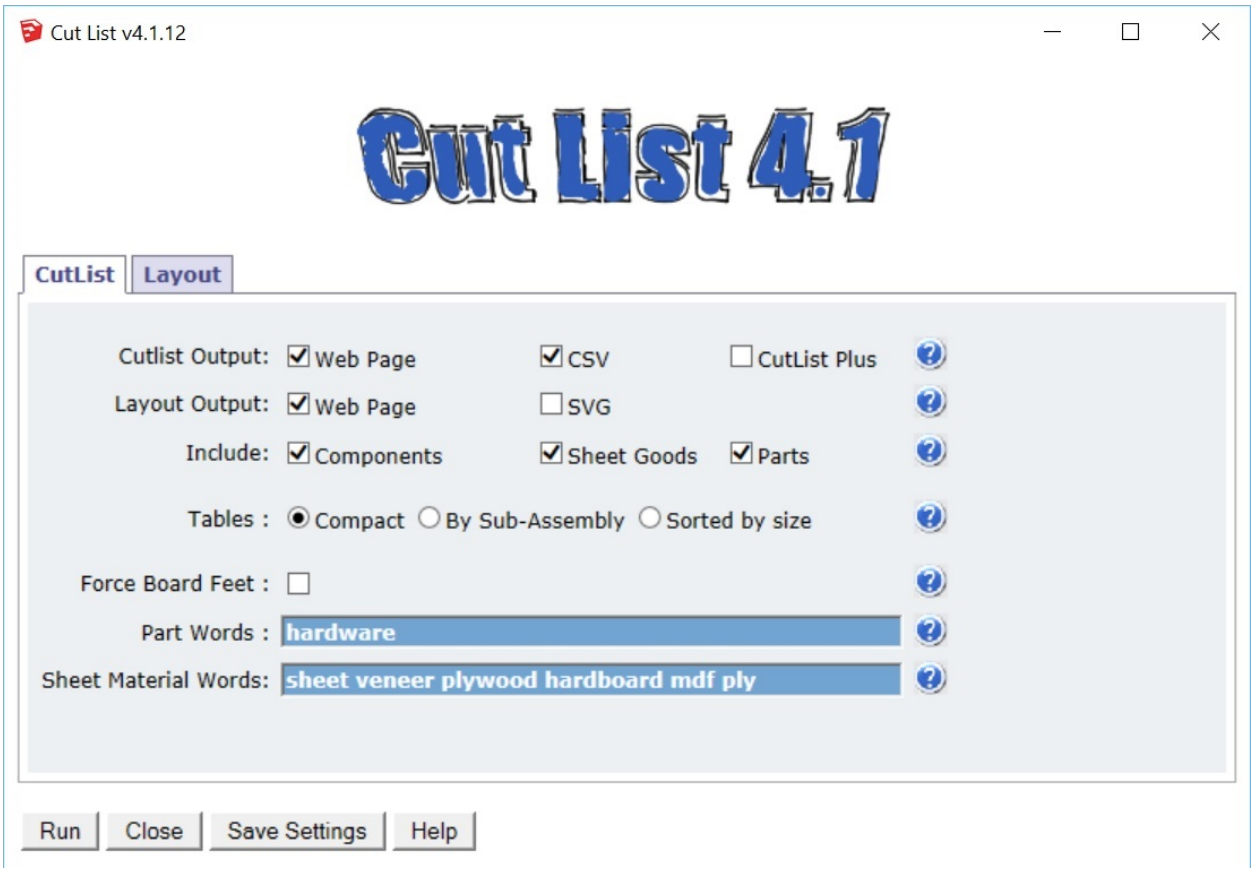

Figure 29. Opening Window

Figure 30 shows the second window. Notice that a kerf (that is, the saw blade cutting width) of 1/8” has been selected. Also, 6” (5 1/2”) wide boards that are 8’ long are selected here.

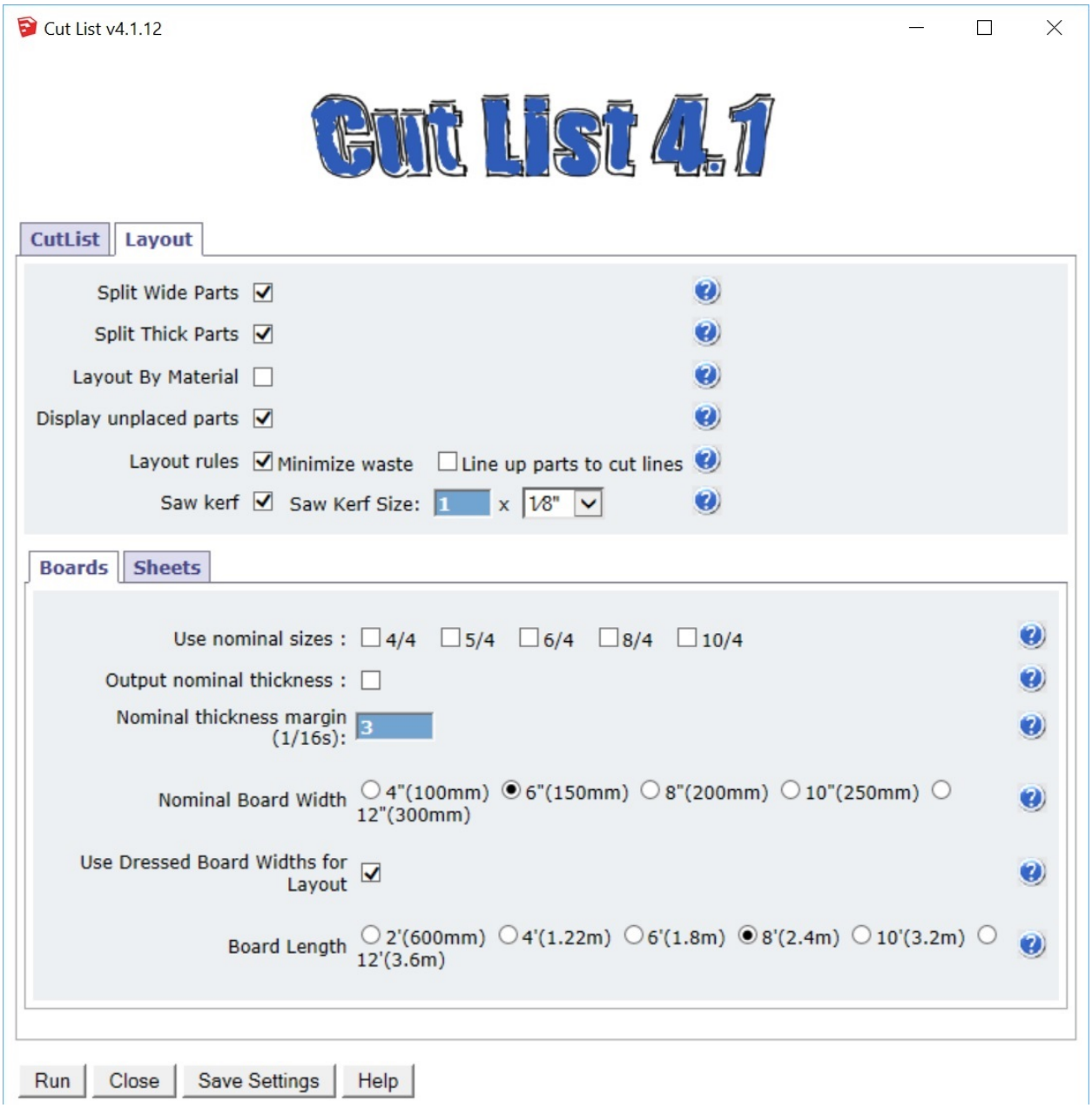

Figure 30. Second Window

Finally, the third and final Cut List 4.1 window is shown in Figure 31. The use of 4’x8’ sheets is selected here.

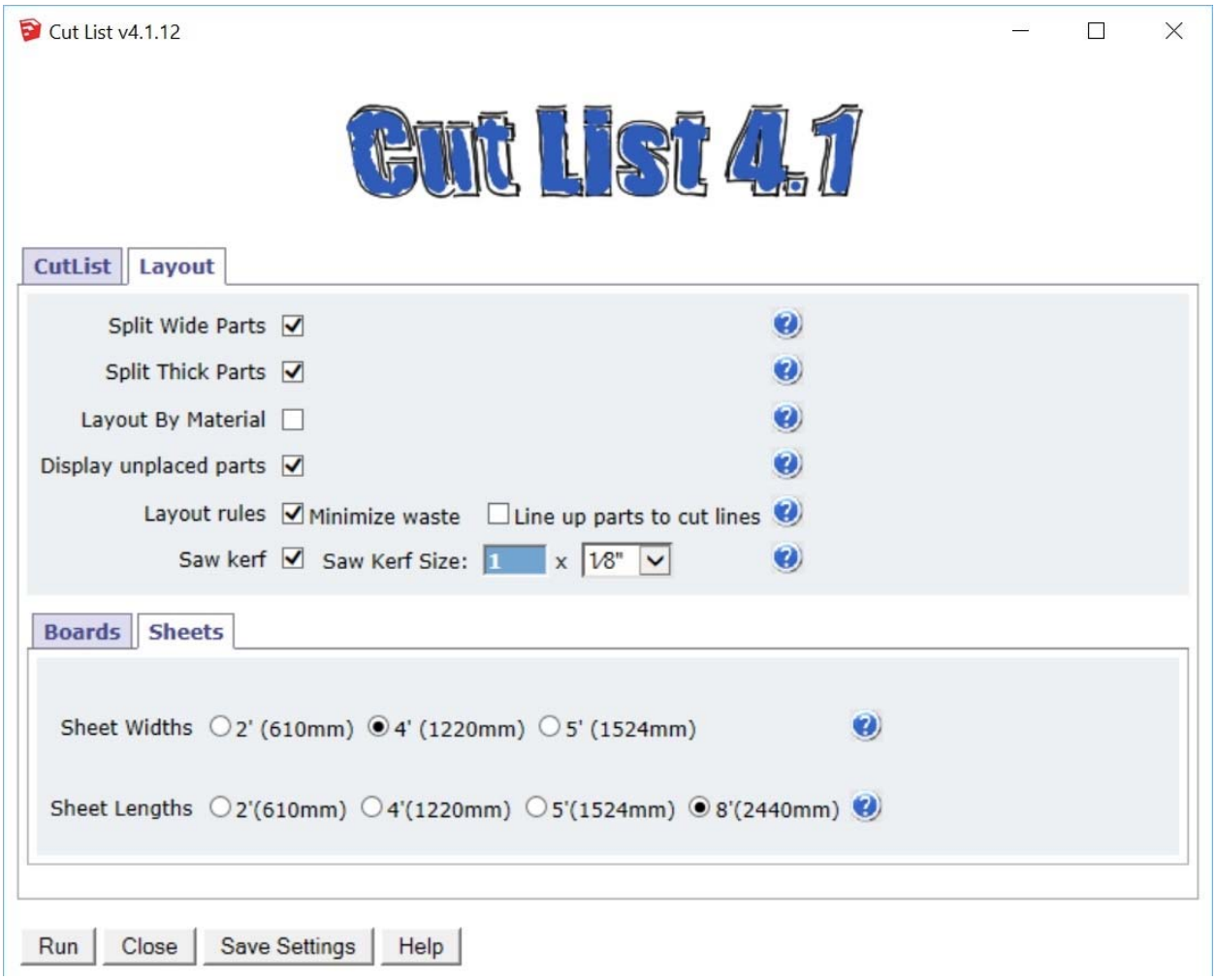

Figure 31. Third Window