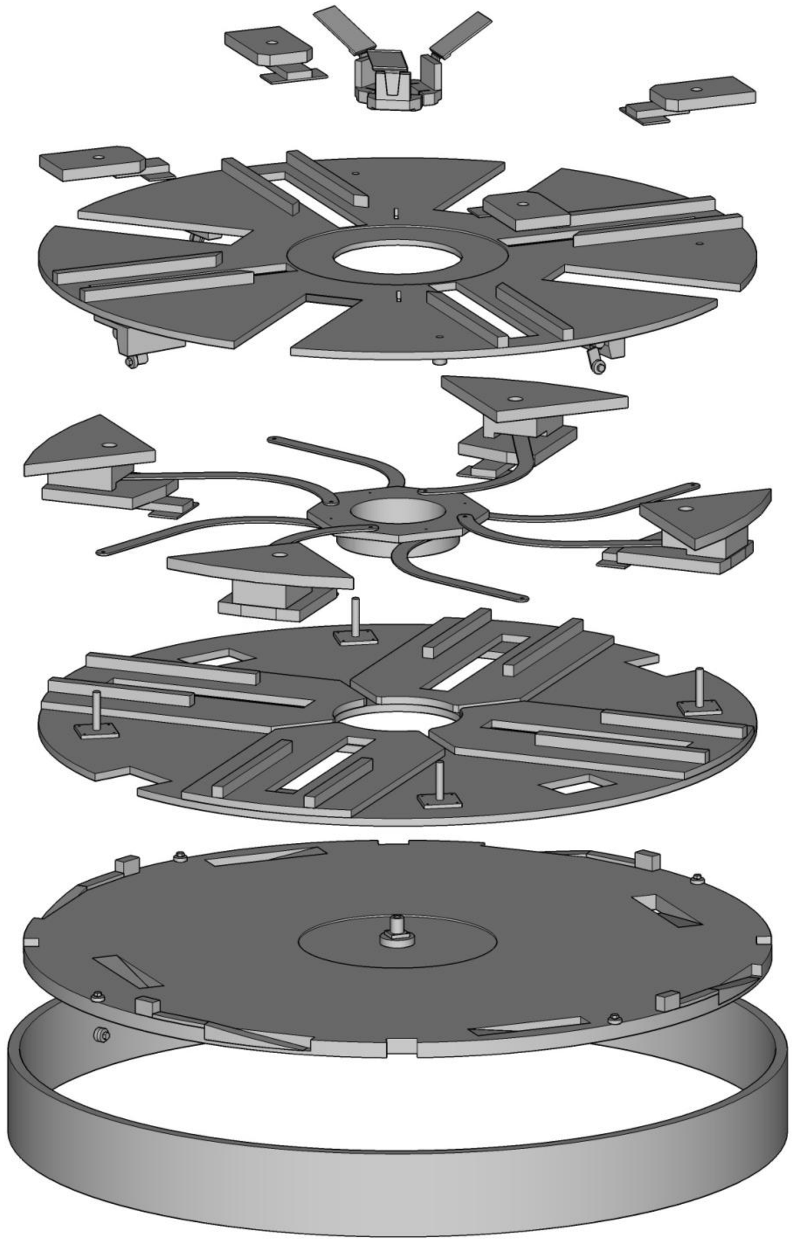
Expanding Table Plans



By Scott Rumschlag

www.mechanicallumber.com

scott@mechanicallumber.com

Version 1.05

Introduction

Thank you for purchasing my plans. I've spent about 600 hours building, modifying, rebuilding and re-modifying this table, so it's been very gratifying to receive so much interest. The income from plans also helps to fund future projects and videos.

This is an advanced project. While I have done my best to document all aspects of the design, some areas require fine tuning and adjustment based on your individual conditions. This project also requires a few metal components, though I've done my best to limit their complexity. Wood is a great medium for quickly experimenting with parts and shapes but some components, like the linear slides, are impractical without steel.

<u>General Notes</u>

- Unless otherwise noted, all dimensions are actual.
- I've done my best to integrate metric dimensions below. Keeping the drawings clear with two sets of dimension can be challenging but I did my best. Maintaining two sets of drawings, one for each system, would be cumbersome and require separate sales and update distribution procedures.
- Playing cards make great shims and most new ones are 0.011" (0.28 mm). I use them here to construct slides with specific amounts of play.
- All parts and layouts are symmetrical unless otherwise noted. All slides on a given level should be as close to 90° from one another as possible.
- Final alignment of slides is extremely important.
- The 2x6 leg frame (1.5" x 5.5" (40 x 140 mm) actual) is simply what I used in my construction. Any solid, stable leg system should work fine. None of the table mechanism extends below the support level.
- Attempts to scale this design to a different size are up to you and may require significant experimentation.
- Scaling this design to a 6 piece design also receives my best wishes, but I feel it's impractical at this size. A larger diameter, with its exponential increase in area, may be feasible.
- I put a lot of effort into minimizing the table thickness, the thinner the better for comfort and leg clearance.

<u>Tools Required</u>

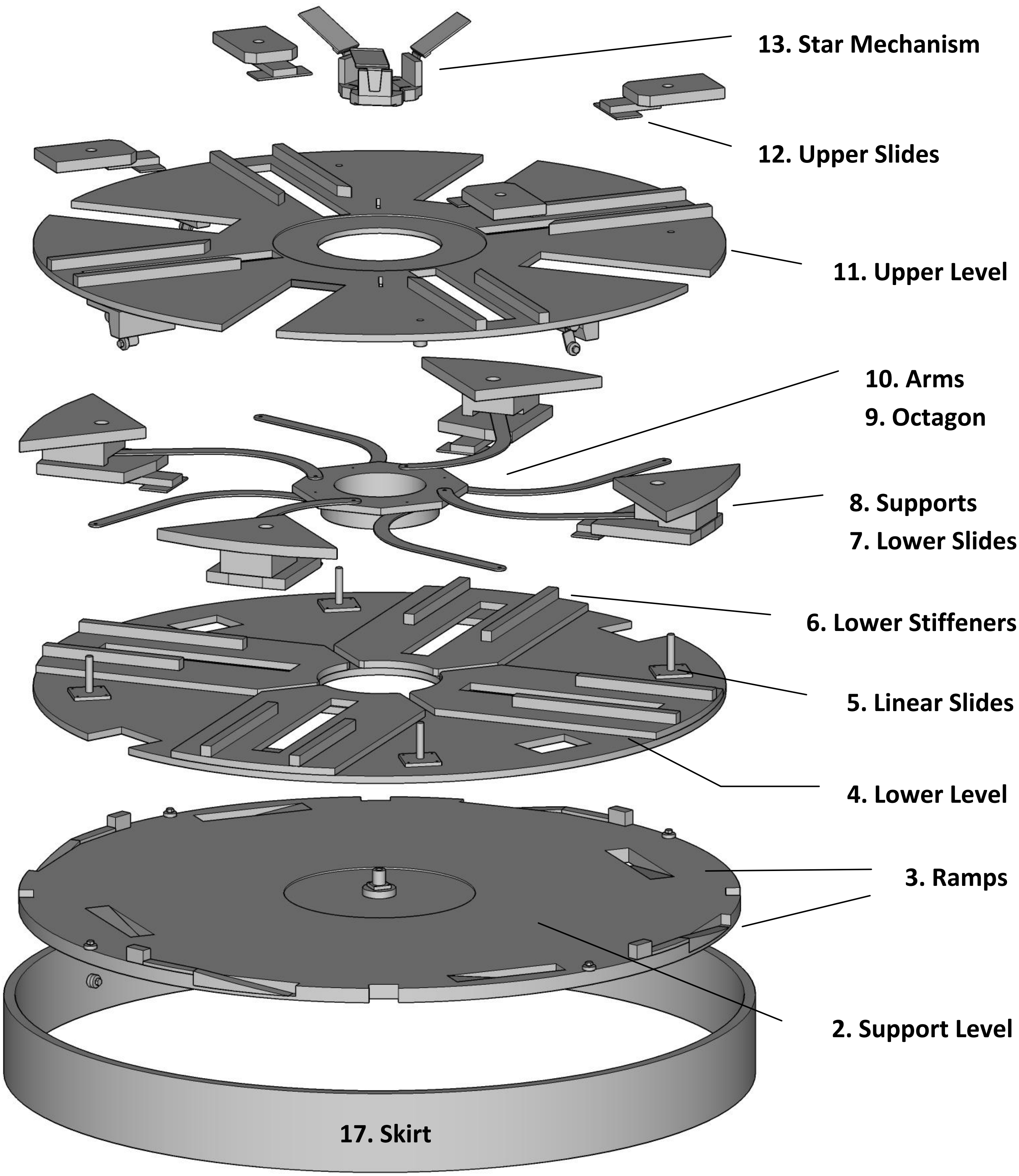
- Table saw
- Jig saw with wood and metal blades
- Router with flush trim and long (2" or 50 mm) mortising bit
- Router trammel
- Glue and clamps
- Thickness planer
- Framing square or squaring system
- Angle grinder with abrasive steel blade
- Hacksaw
- Vise
- Propane torch (optional)
- Drill press (optional)

Materials Required / Parts List

- Qty 5 - 5'x5' (1500 x 1500 m) sheets of 1/2" (12 mm) (Baltic birch or equivalent dense plywood) You will have roughly 1/2 sheet left over.
- Ash or hickory for gluing up the slides, the equivalent of a 6" x 8' (150 x 2500 mm) board is sufficient.
- 1/8" x 16" x 30" (3 x 400 x 800 mm) steel or aluminum sheet for arms, slide bottoms and star levers.
- 2 x 12 mm hardened shaft and 5 x linear slides
  - *12 mm Inner Dia 21 mm OD LMK12UU Square Linear Ball Bearing*
    - Current link: http://www.amazon.com/gp/product/B0081OY706/ These seemed to be the best compromise between price, size and availability.
  - *Linear Motion 12 mm Shaft, 13" Length, Chrome Plated, Case Hardened, Metric*
    - Current link: http://www.amazon.com/gp/product/B002BBJ0CA You only need about 16" (400 mm) but a little extra rarely hurts and I did not find it in other lengths.
- 4 bolts and nylon lock nuts for connection of arms to upper slides, I used 1/4-20 x 3" (M6x1 x 75 mm) bolts, then cut them to size.
- Tap for above 1/4-20 bolts
- 8 sets of bolt/washer/nylon nut in 5/16" or 8 mm diameter, 1.5" (38 mm) length. (This size matches the ID of skateboard bearings.)
- 4 sets of elevator bolt/washer/nylon nut in 5/16" or 8 mm diameter, 2" (50 mm) length minimum
- Variety of small screws and fasteners, commonly available
- Qty 3 - small hinges, see Figure 38
- 12" (300 mm) lazy susan bearing, low profile preferred
- Wood glue, extended open time and moisture resistant type recommended. Example: Titebond III.
- Qty 1.5 4'x8' (1200 x 2400 mm) sheets of 3/4" (18 mm) plywood for top surface. Glued up hardwood panels may be ideal but this table can tolerate very little warping and I don't recommend it. When I was considering mass production options, I settled on high density foam core fiberglass panels veneered with hardwood as the best solution.
  - The 1.5 sheets figure is based on a most efficient layout with regard to waste, aligning the surface panels' grain to the table center will increase waste and require additional material.
- Spring loaded gate hinges, or hardware providing similar action, dimensions discussed further down.
  - Example: http://www.homedepot.com/p/Black-Self-Closing-Gate-Kit-13534/202950150
- Qty 16 of 8x22x7 mm shielded bearings, i.e. "skateboard bearings" These are handy for a variety of projects.
  - Current link: http://www.amazon.com/gp/product/B002BBICBK
- For the legs: 3-2x6x8' (40 x 140 x 2400 mm) and 1-2x6x10' (40 x 140 x 3000 mm) common lumber.

Mechanism Drawings & Dimensions

Top surface and legs omitted for clarity



1. Legs

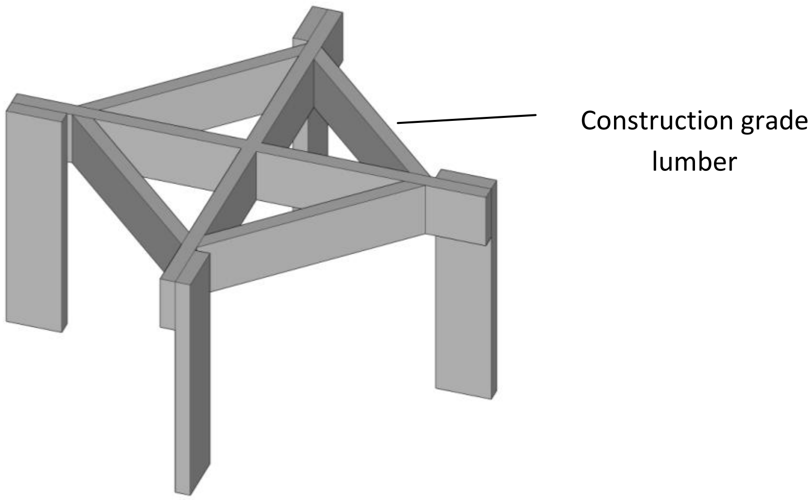


Figure 1: Legs Iso View

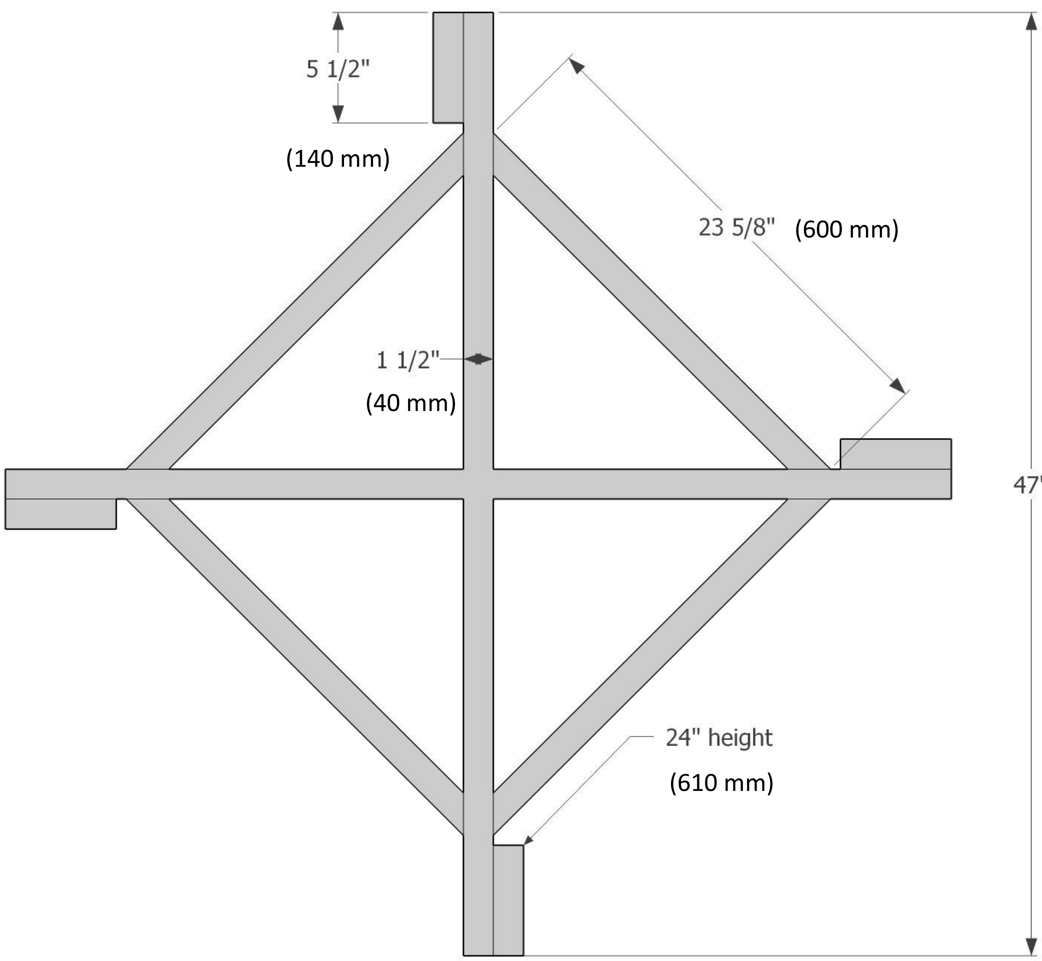


Figure 2: Legs Top View

2. Support Level

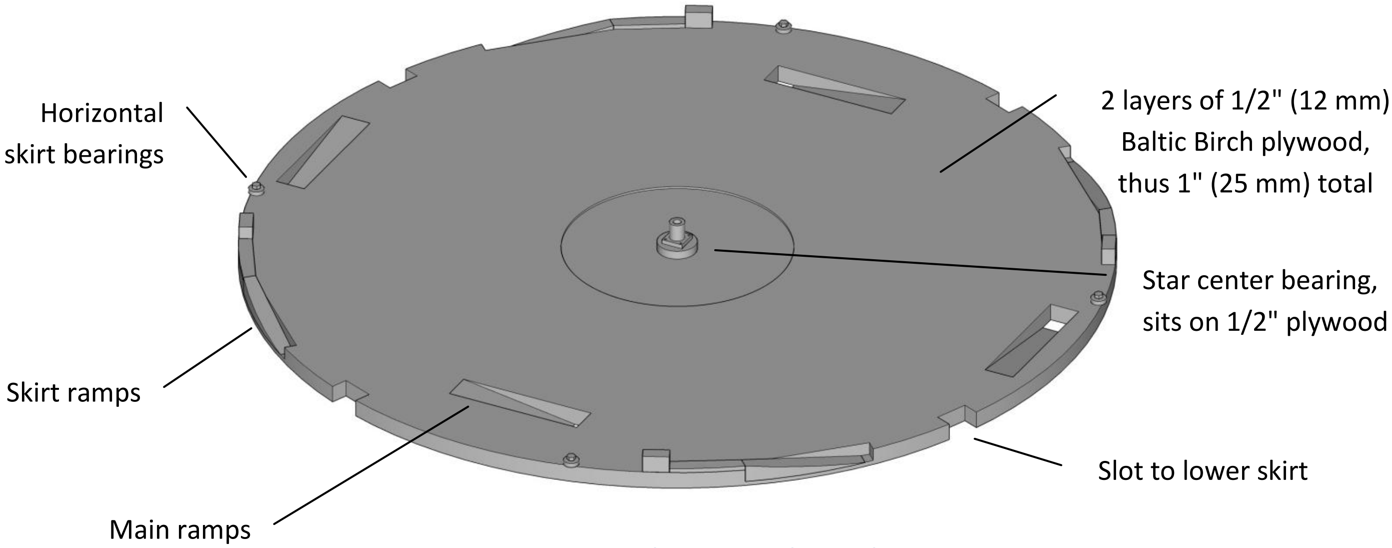


Figure 3: Support Level Iso View With Everything

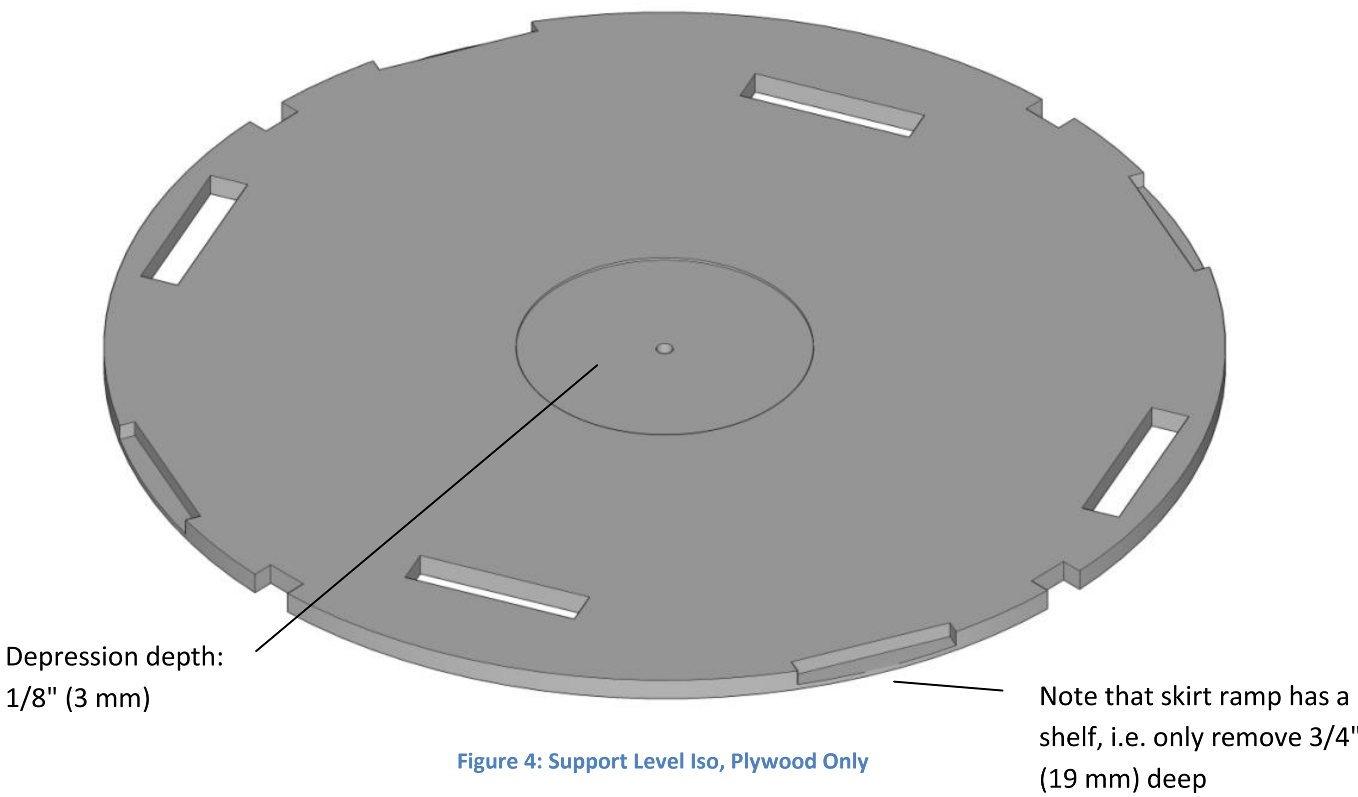


Figure 4: Support Level Iso, Plywood Only

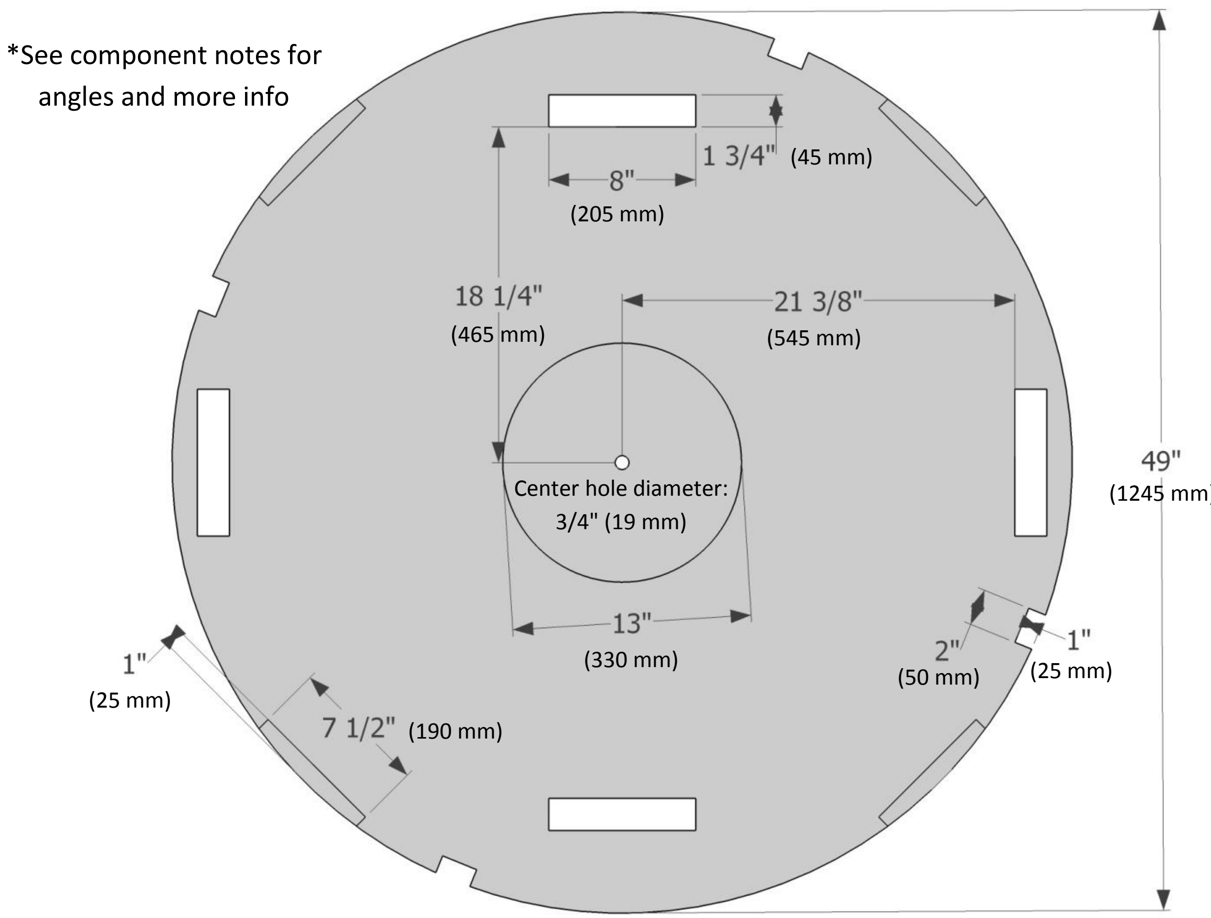


Figure 5: Support Level Top View

3. Ramps - Wide (narrow ramps are identical but only 1" (25 mm) wide

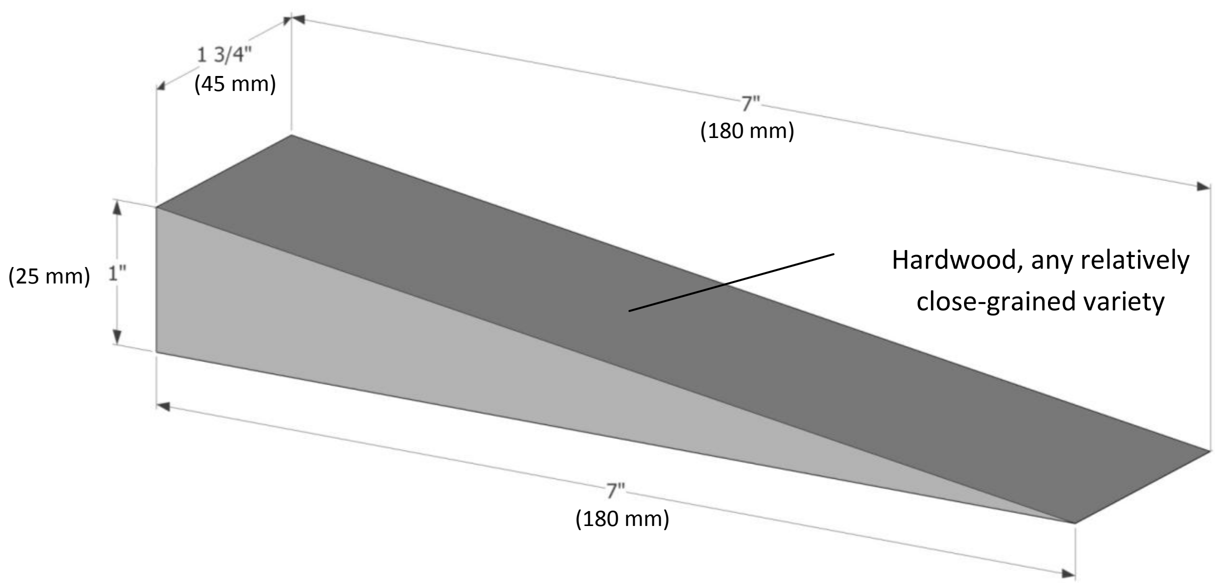


Figure 6: Support Level Ramps Iso View

4. Lower Level

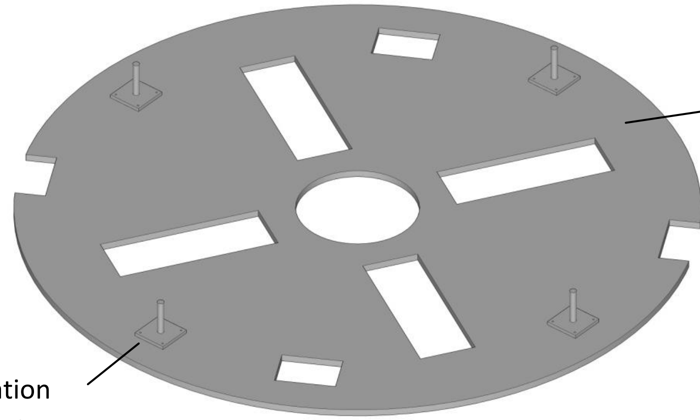


Figure 7: Lower Level Iso View

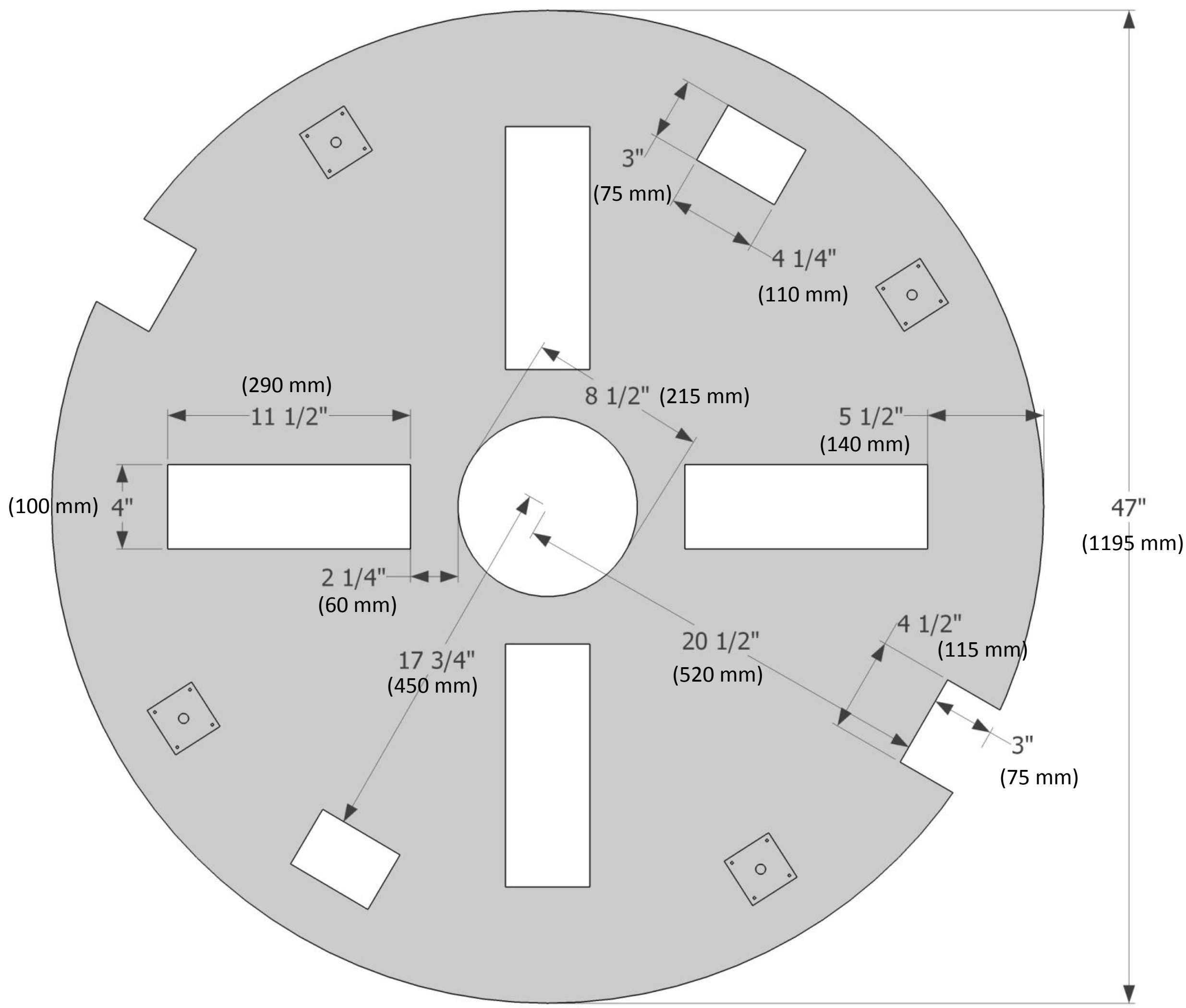


Figure 8: Lower Level Top View

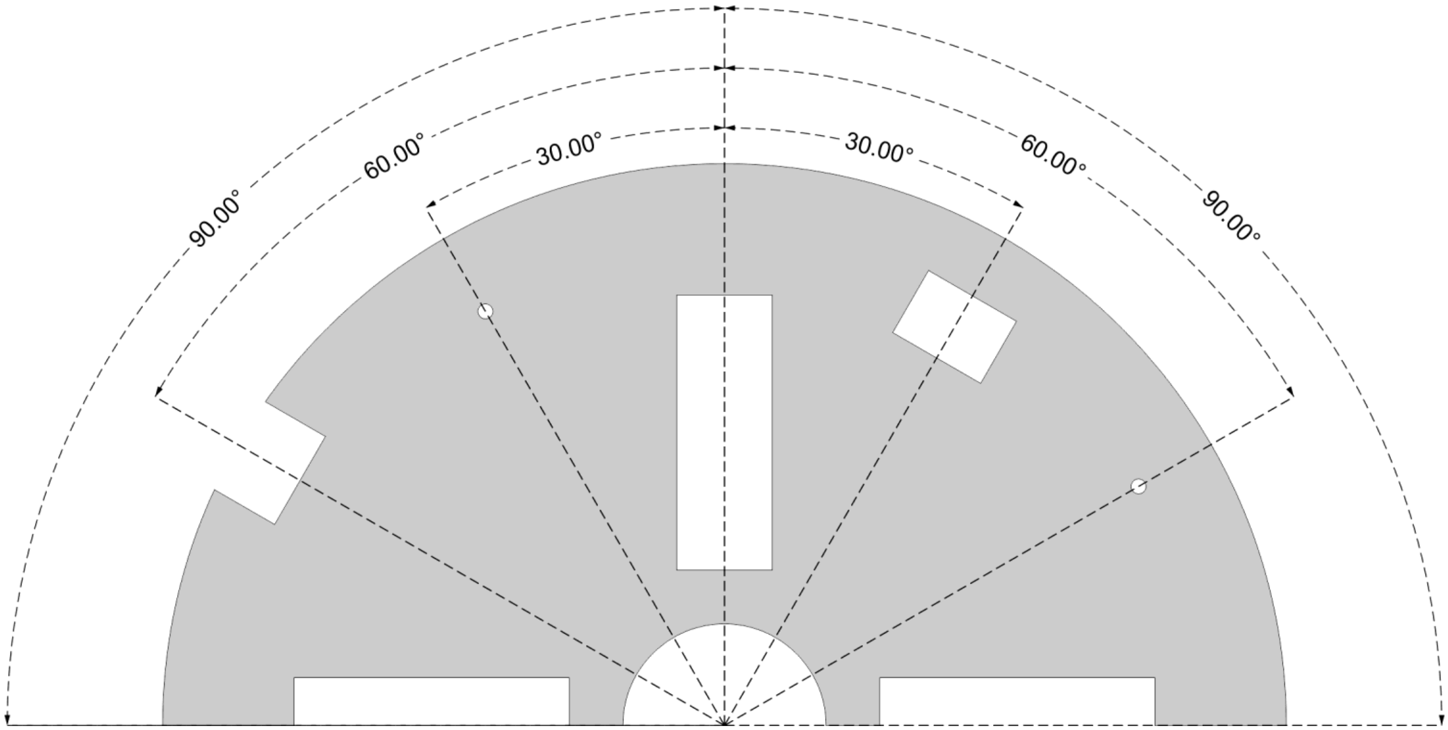


Figure 9: Lower Level Angles

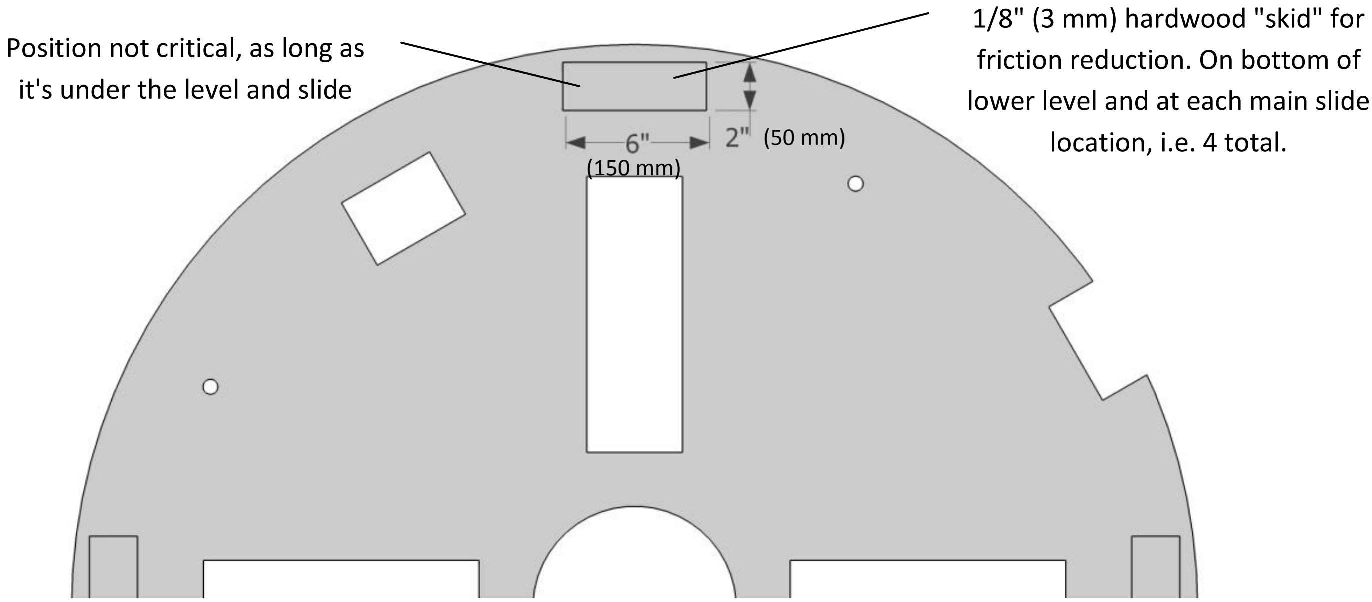


Figure 10: Lower Level Bottom View

5. Linear Slides

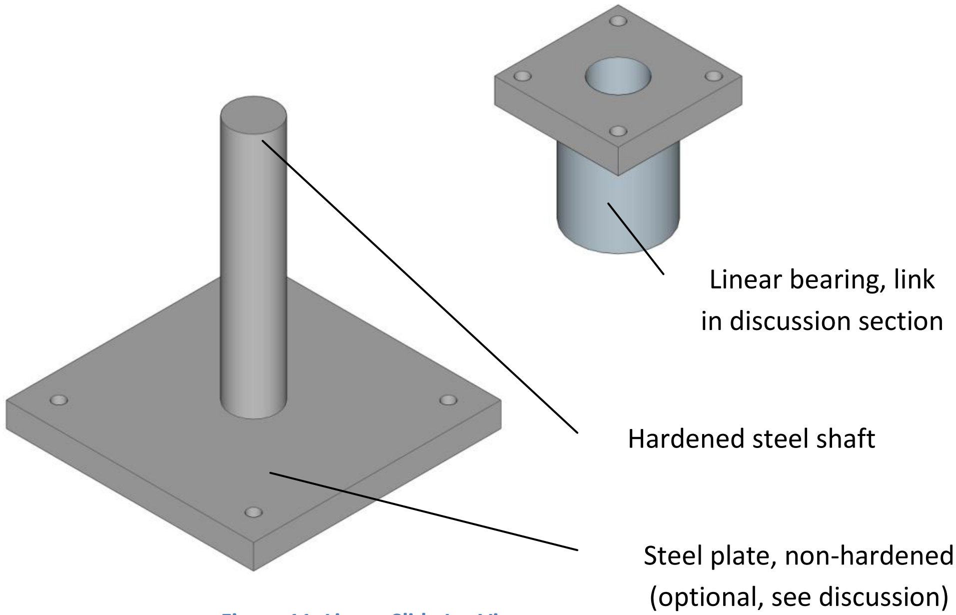


Figure 11: Linear Slide Iso View

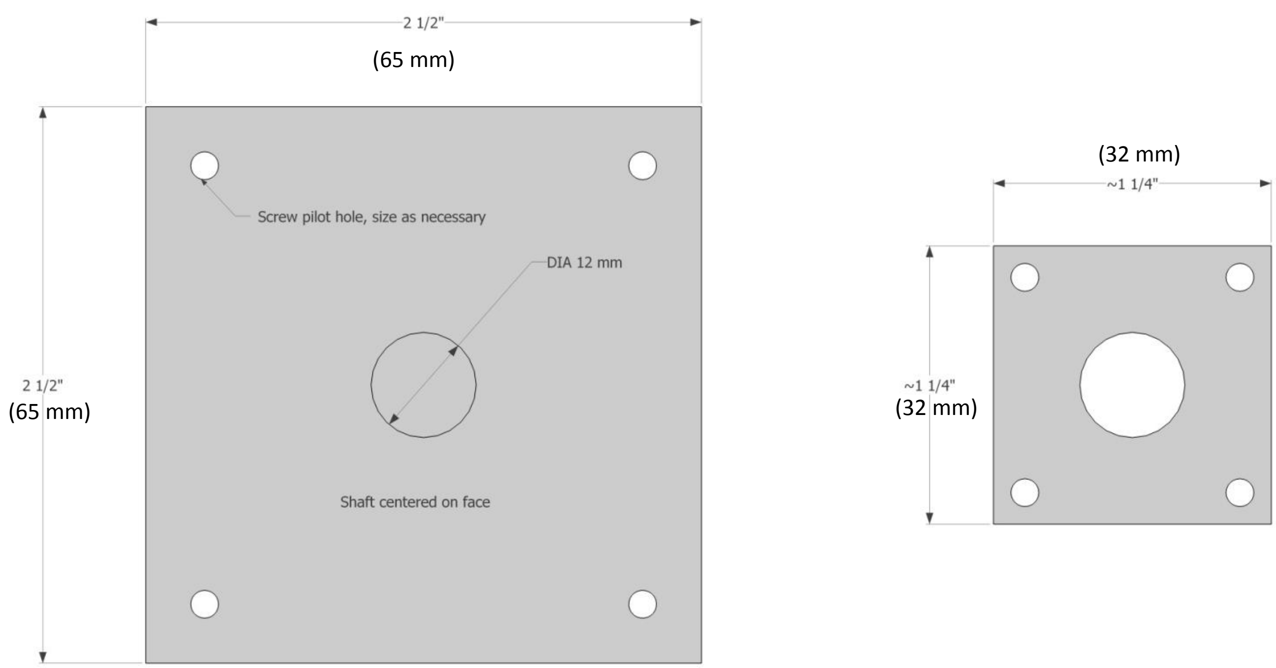


Figure 12: Linear Slide Top View

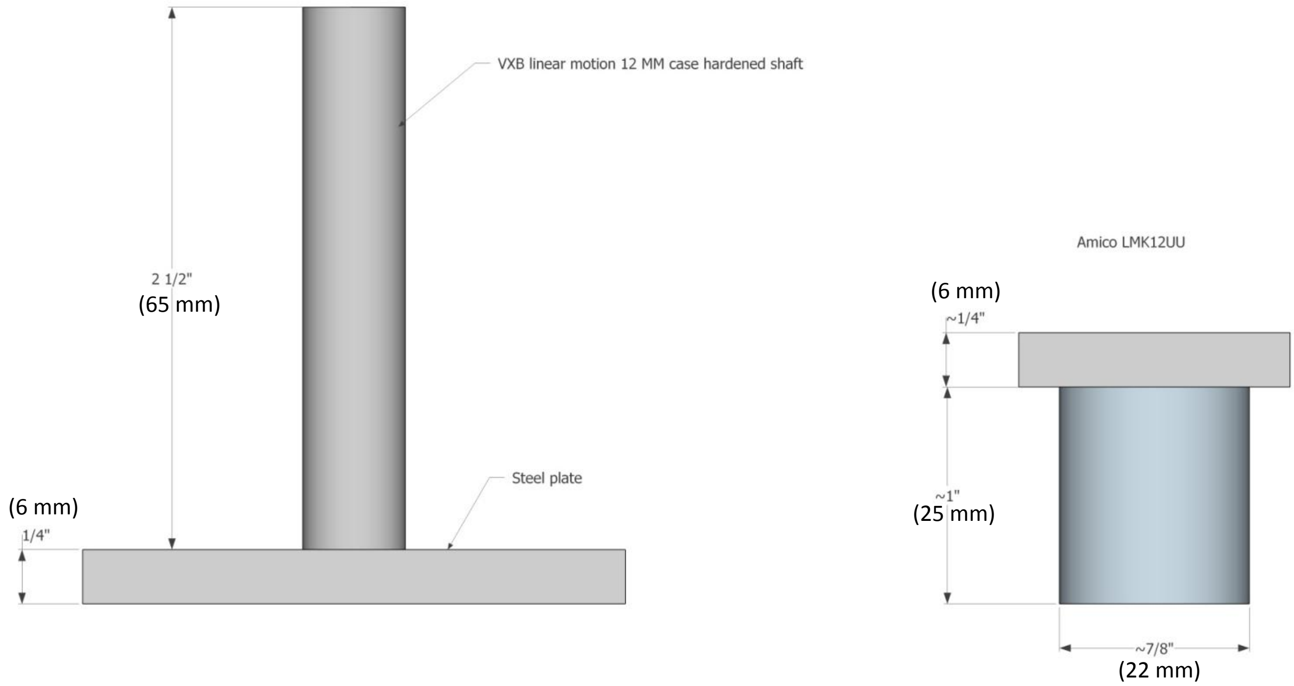


Figure 13: Linear Slide Side View

6. Lower Stiffeners

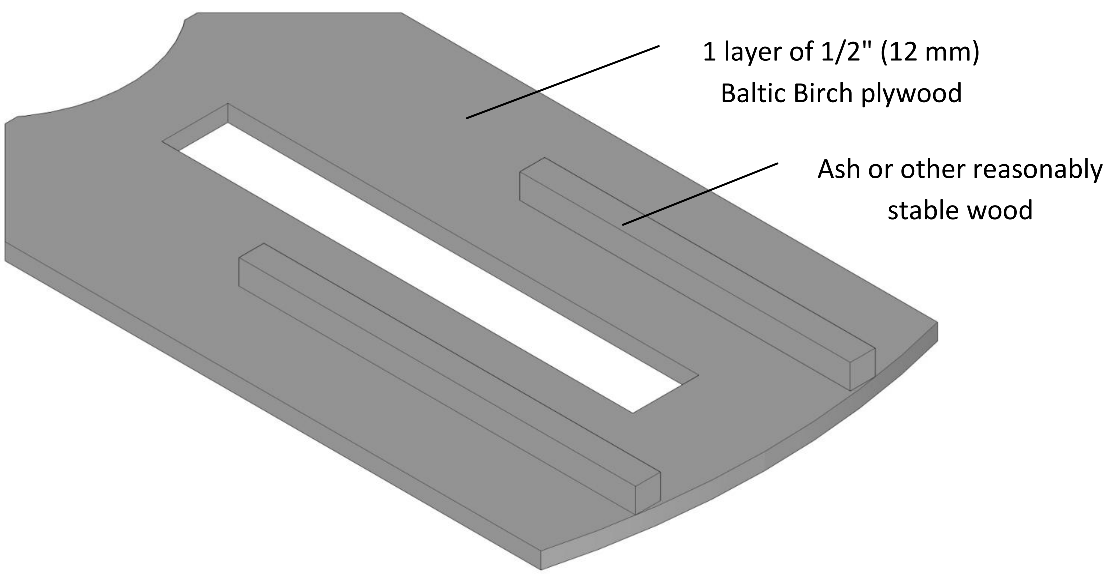


Figure 14: Lower Stiffener Iso View

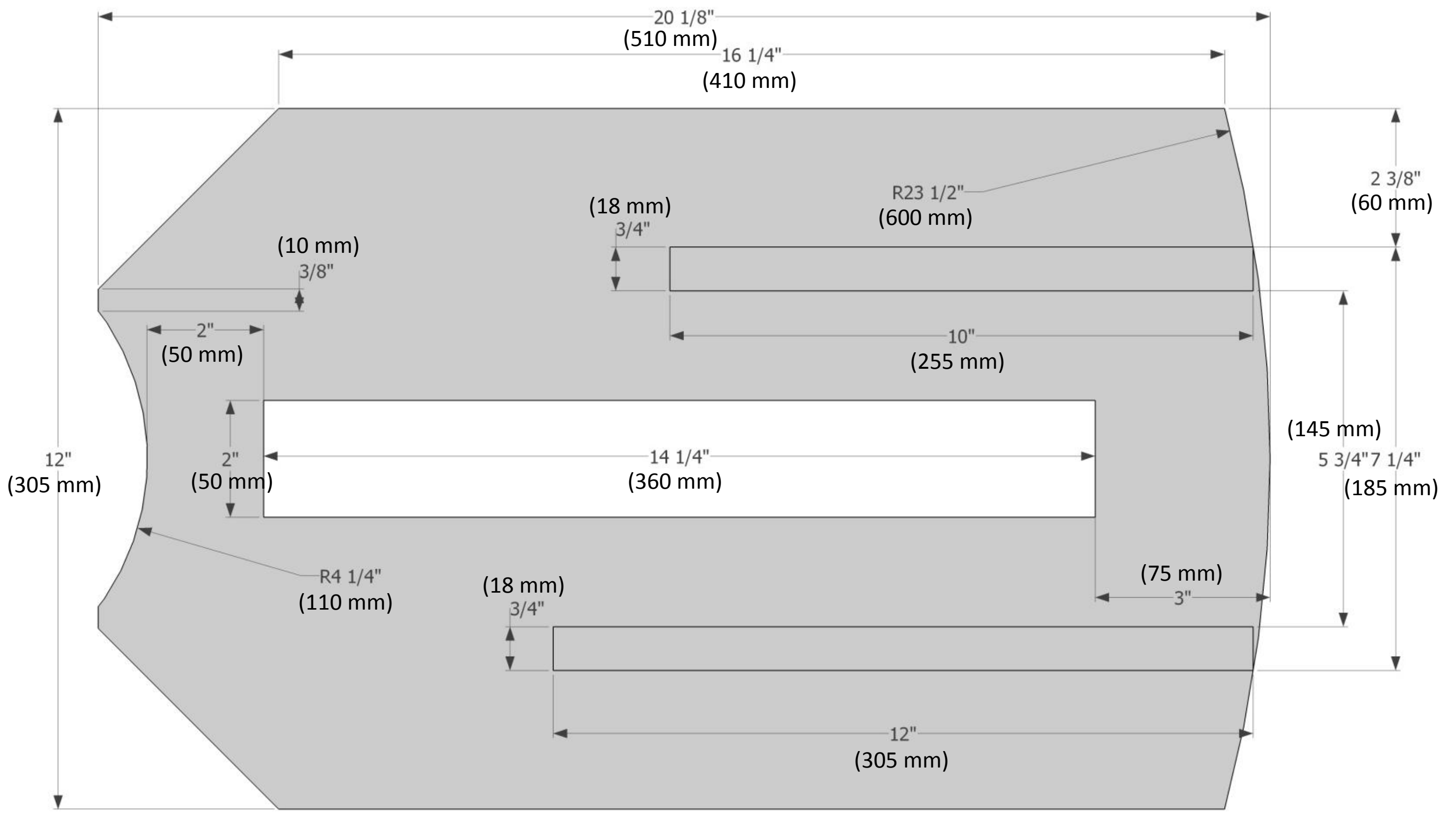


Figure 15: Lower Stiffener Top View

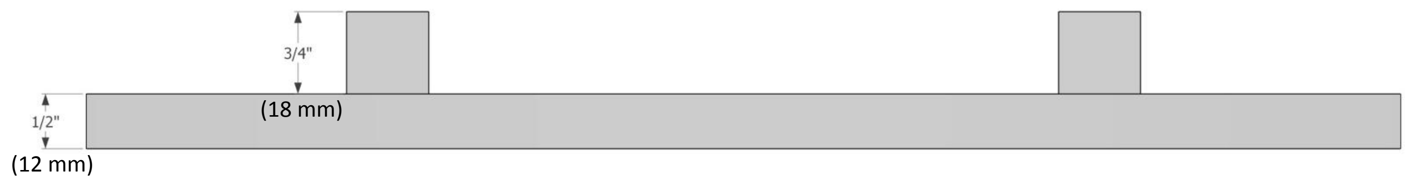


Figure 16: Lower Stiffener Side View

7. Lower Slides

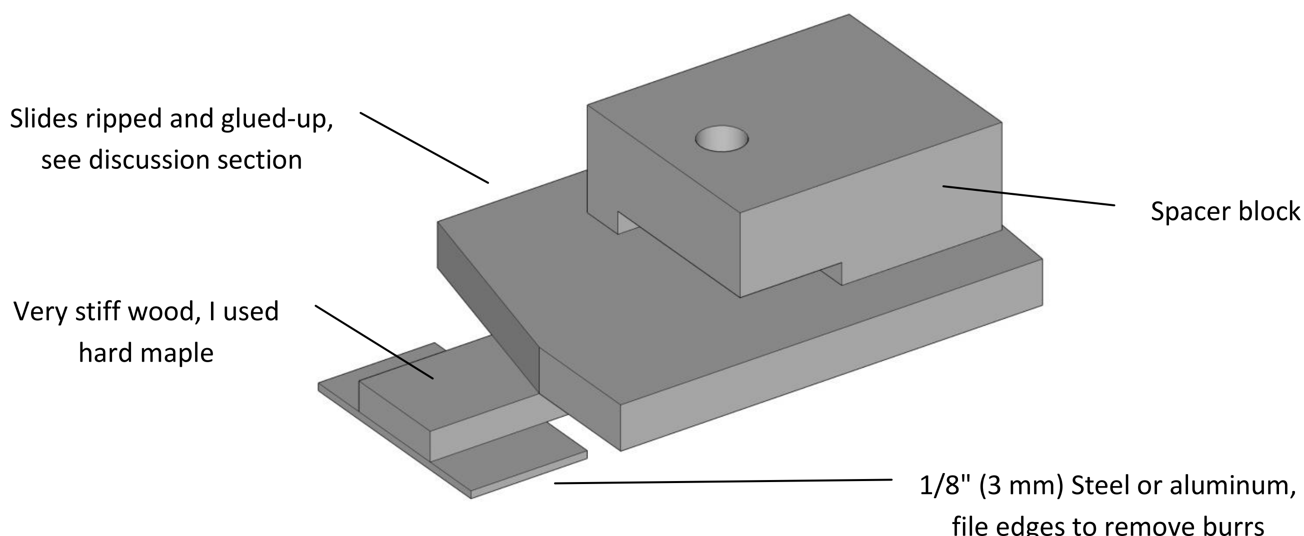


Figure 17: Lower Slide Iso View

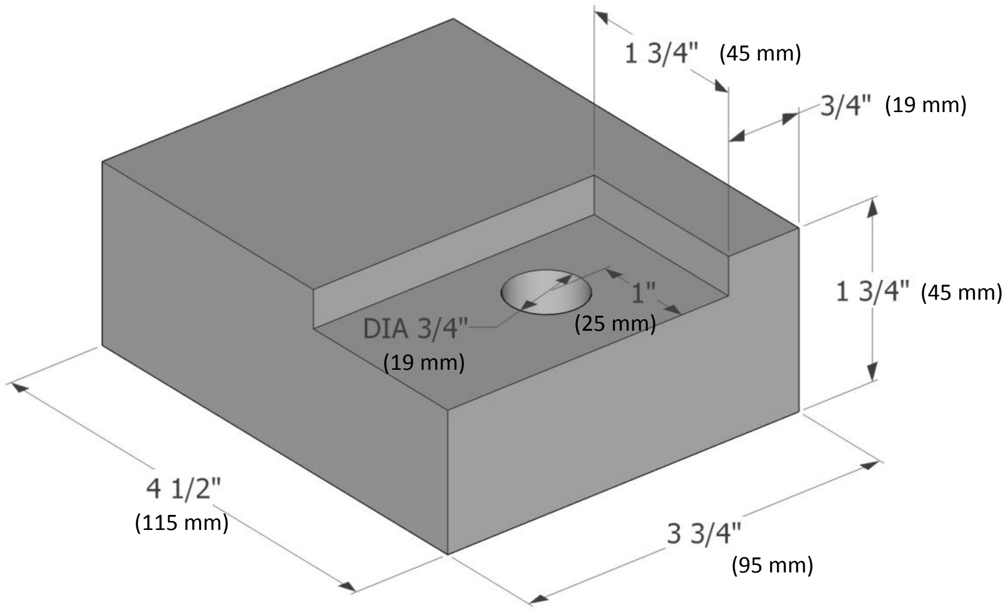


Figure 18: Spacer Block Close-up

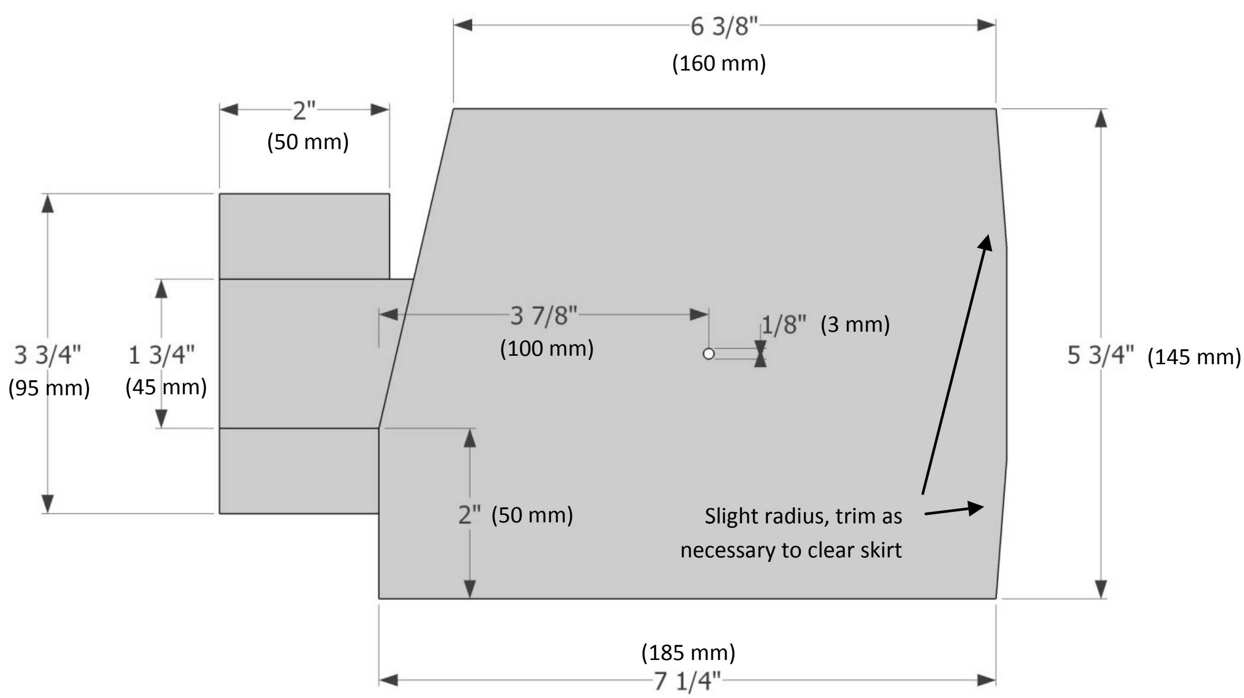


Figure 19: Lower Slides Top View

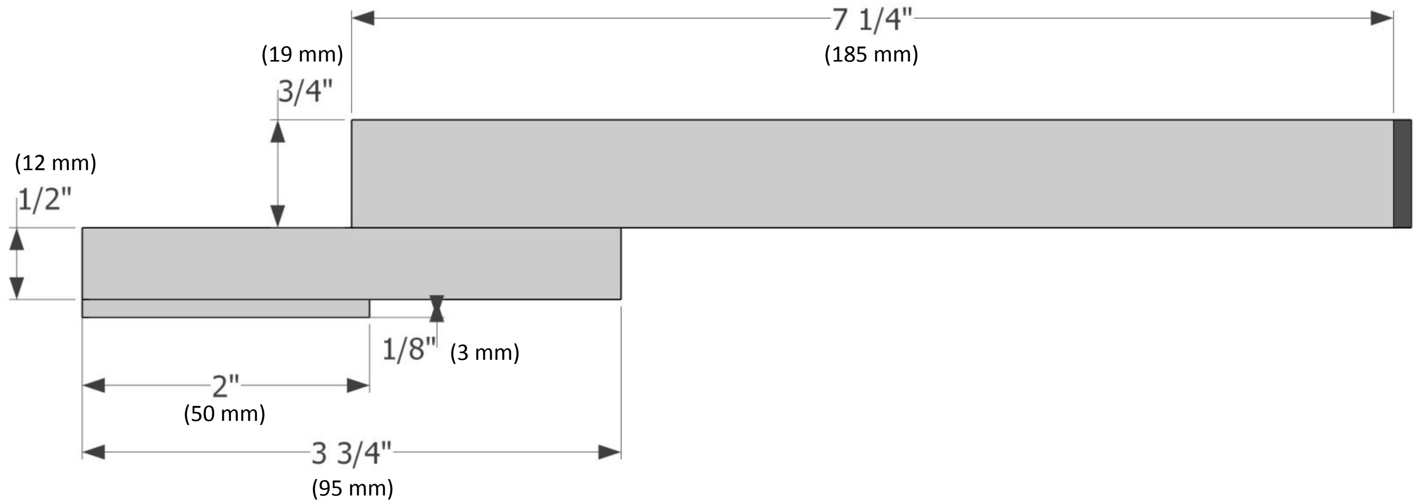


Figure 20: Lower Slide Side View

8. Supports

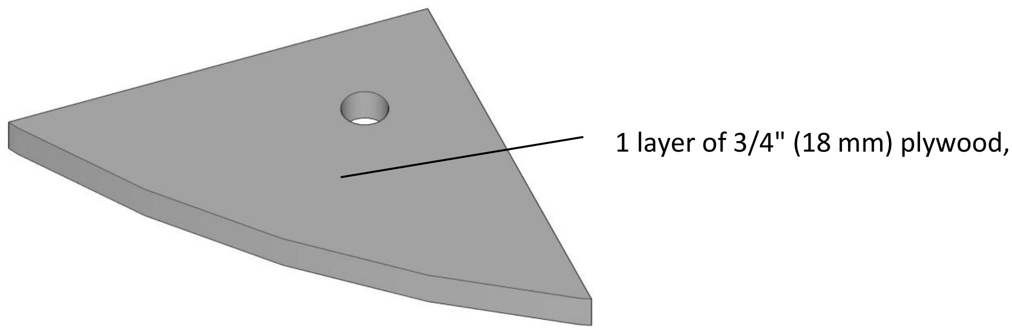


Figure 21: Lower Slide Supports Iso View

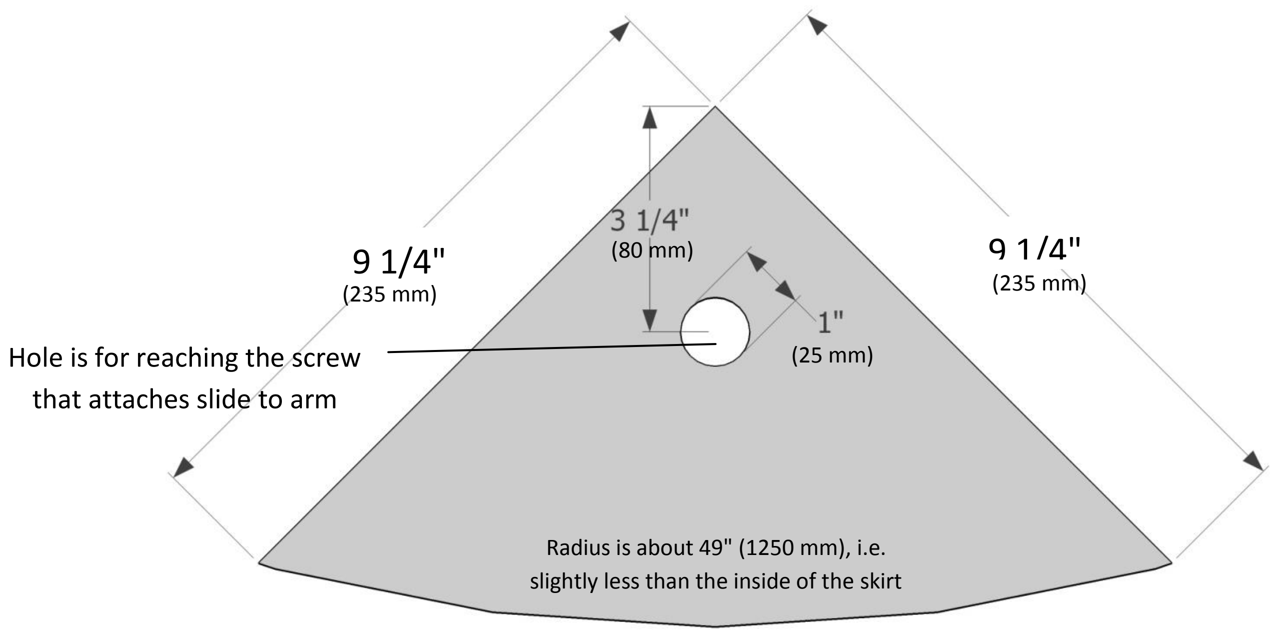


Figure 22: Lower Slide Supports Top View

9. Octagon

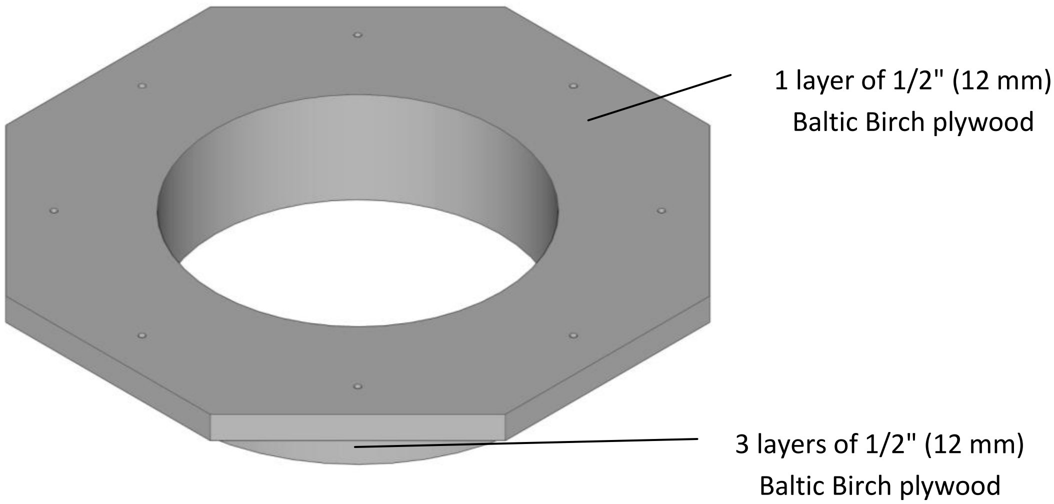


Figure 23: Octagon Iso View

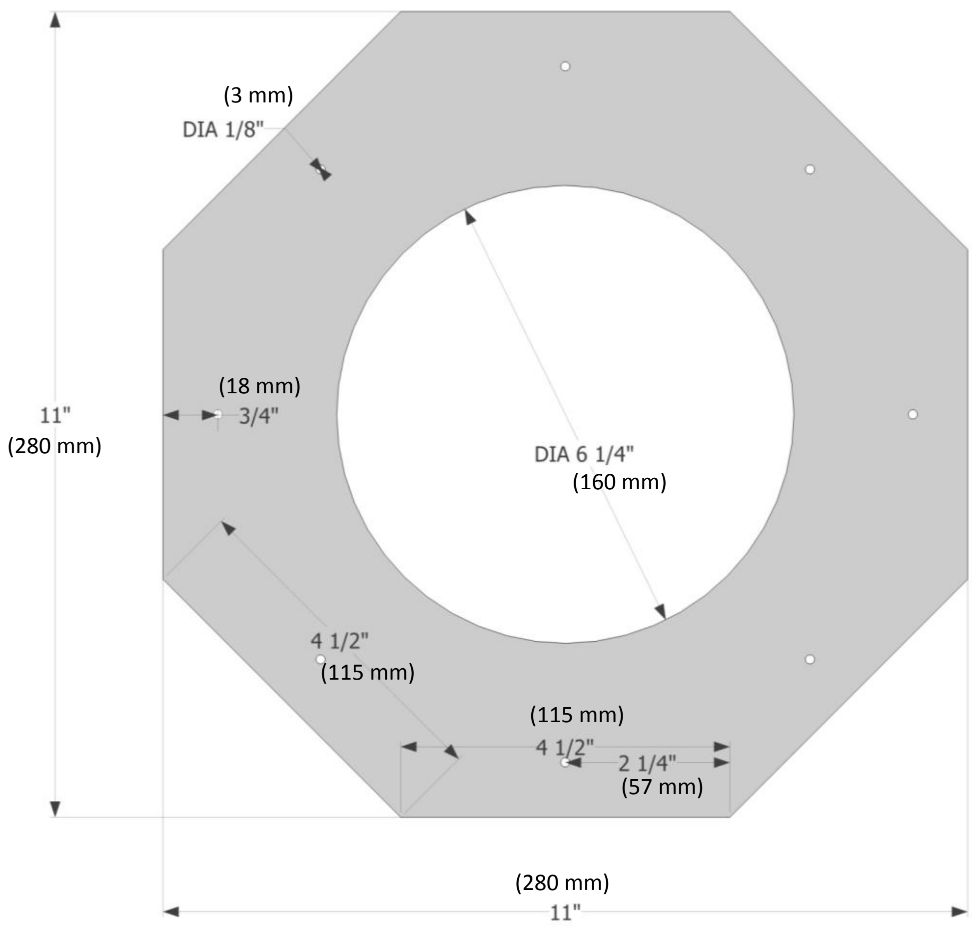


Figure 24: Octagon Top View

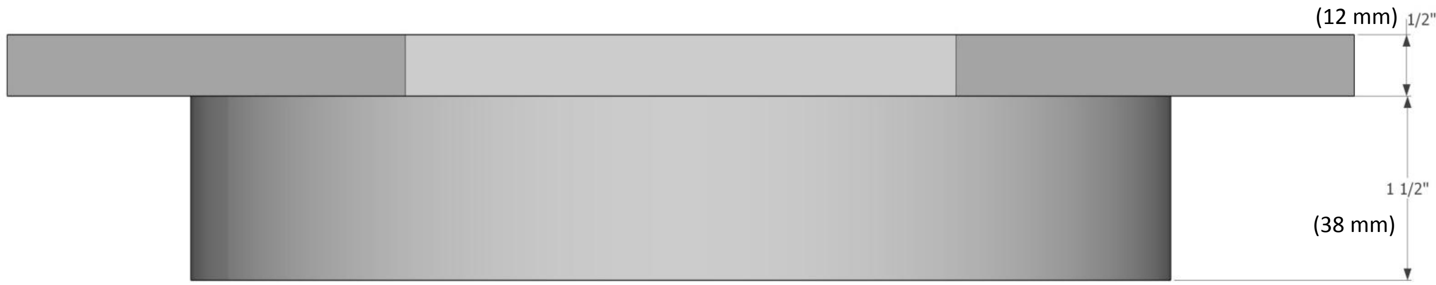


Figure 25: Octagon Side View

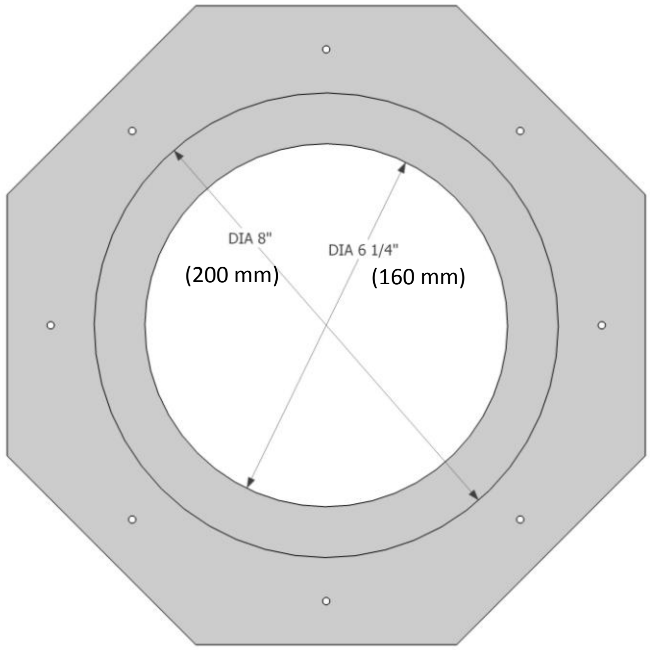


Figure 26: Octagon Bottom View

10. Arms

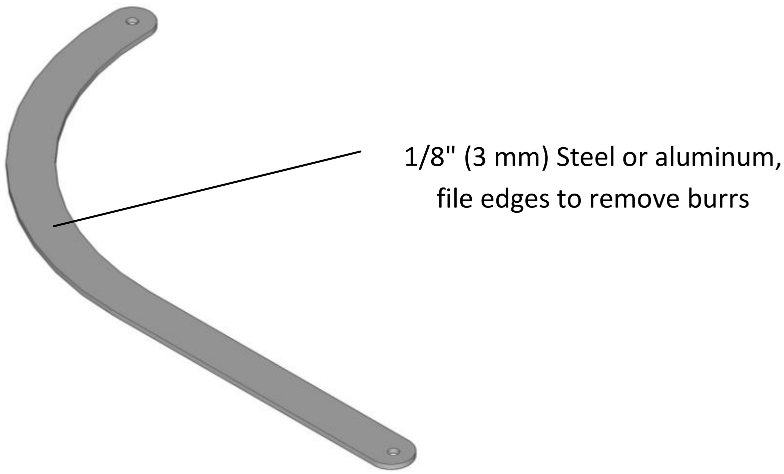


Figure 27: Octagon Arms Iso View

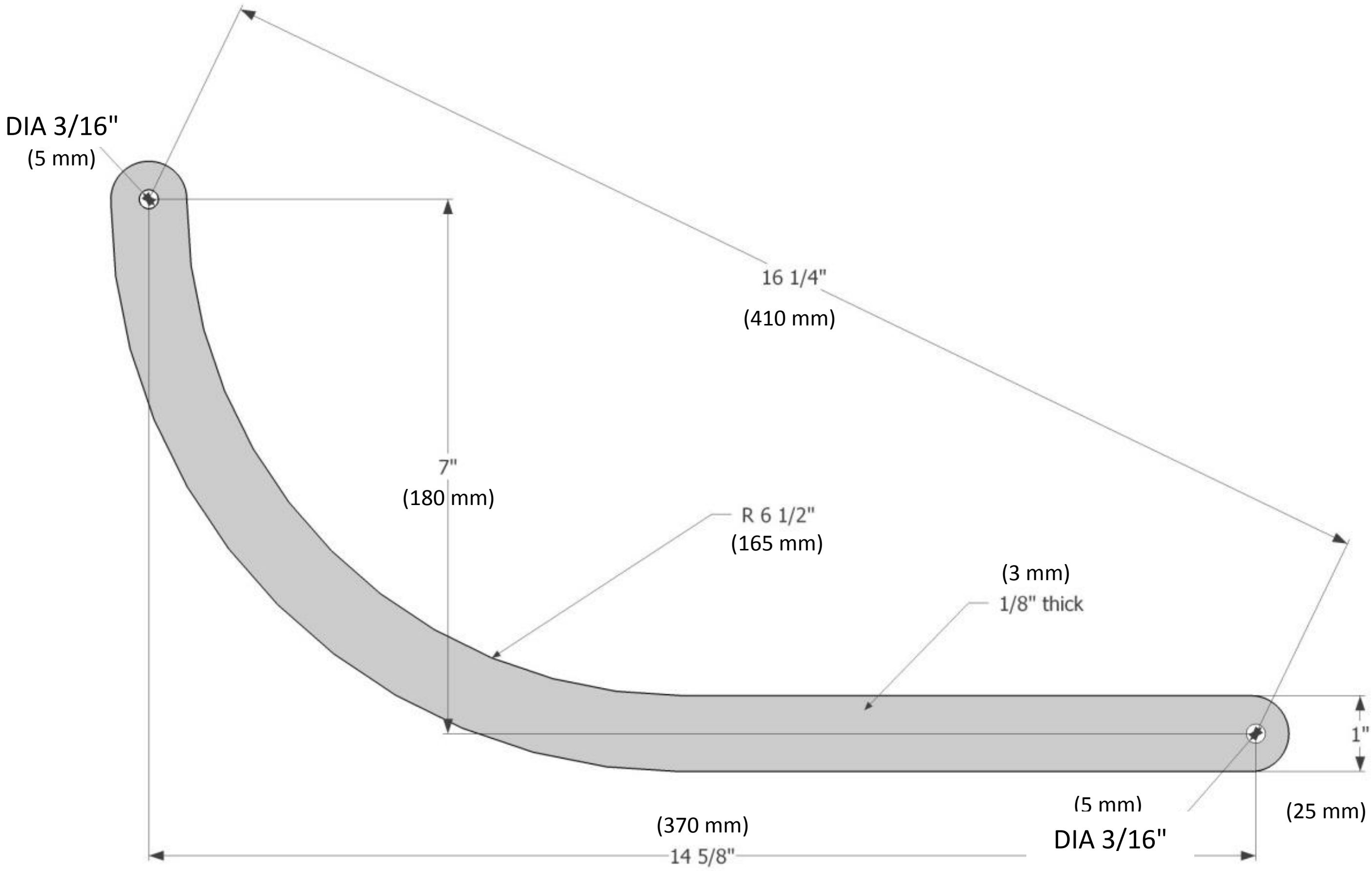


Figure 28: Octagon Arms Top View

11. Upper Level

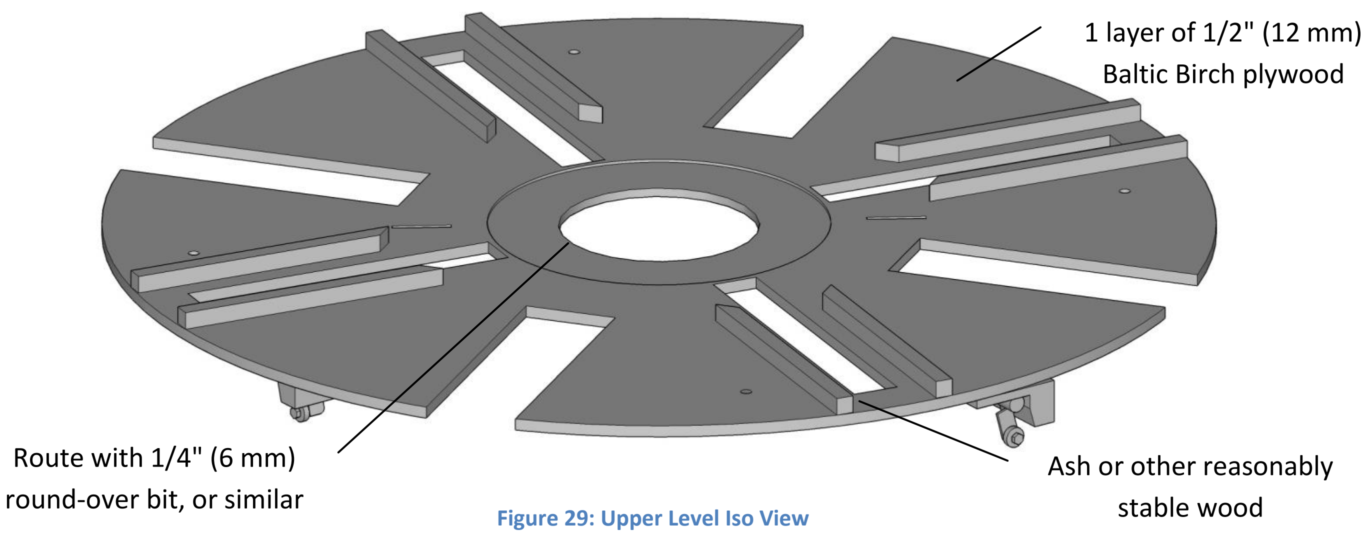


Figure 29: Upper Level Iso View

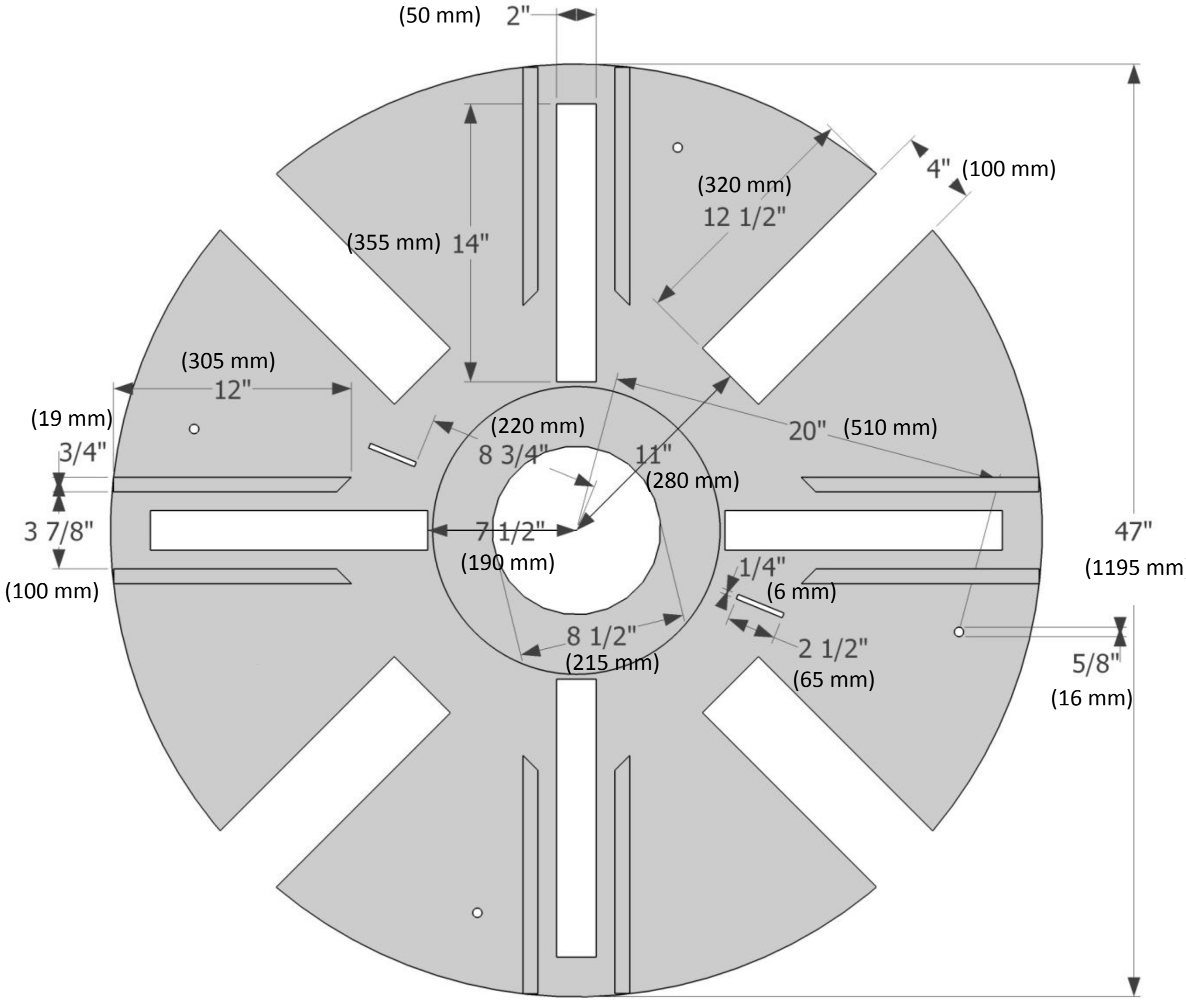


Figure 30: Upper Level Top View

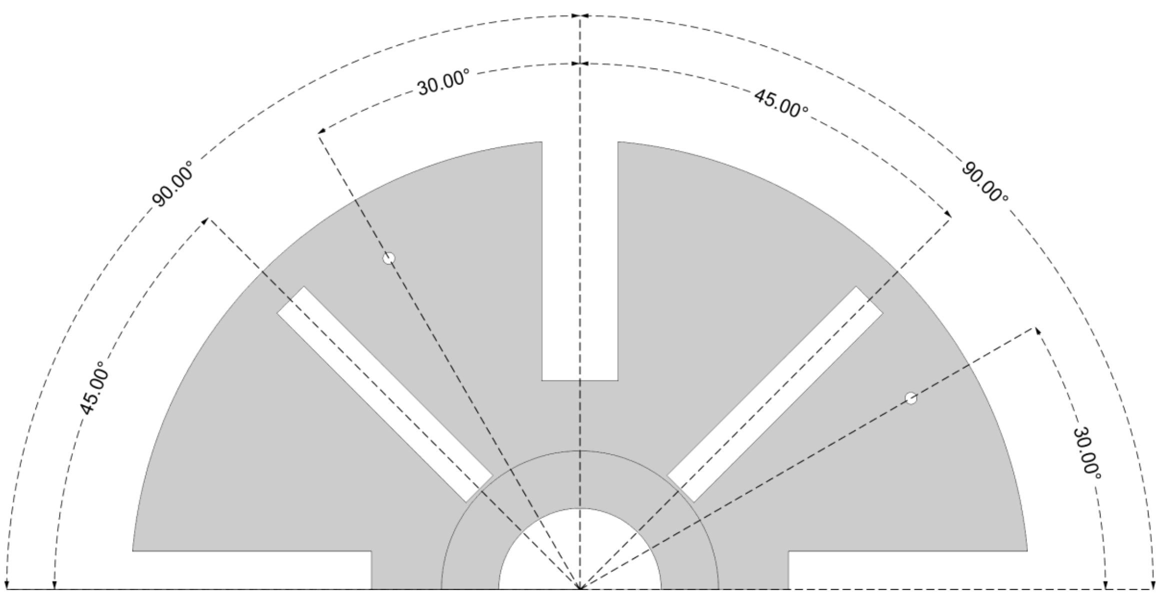


Figure 31: Upper Level Angles

12. Upper Slides

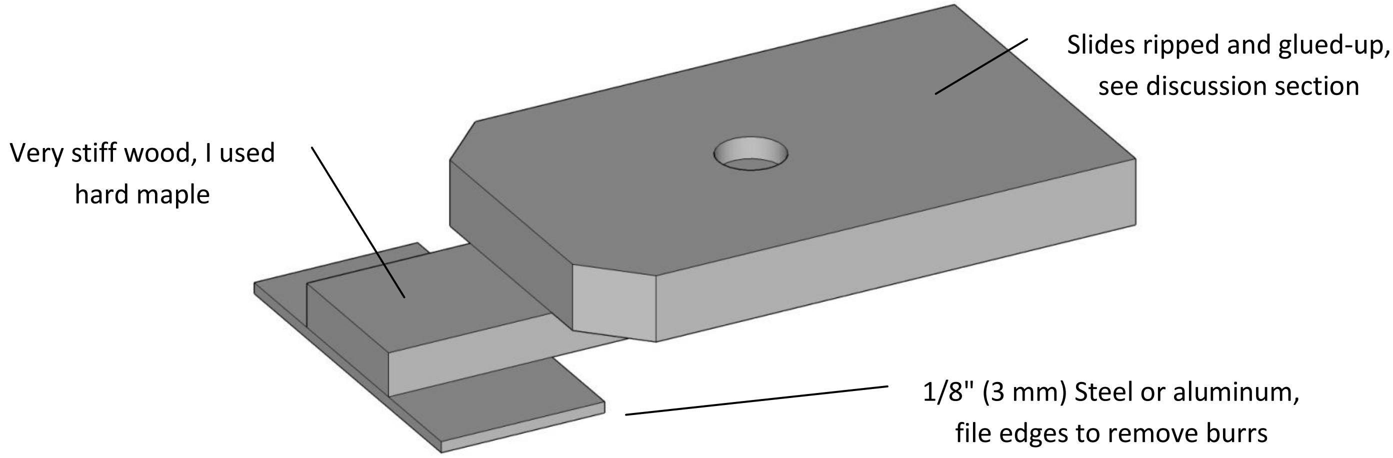


Figure 32: Upper Slides Iso View

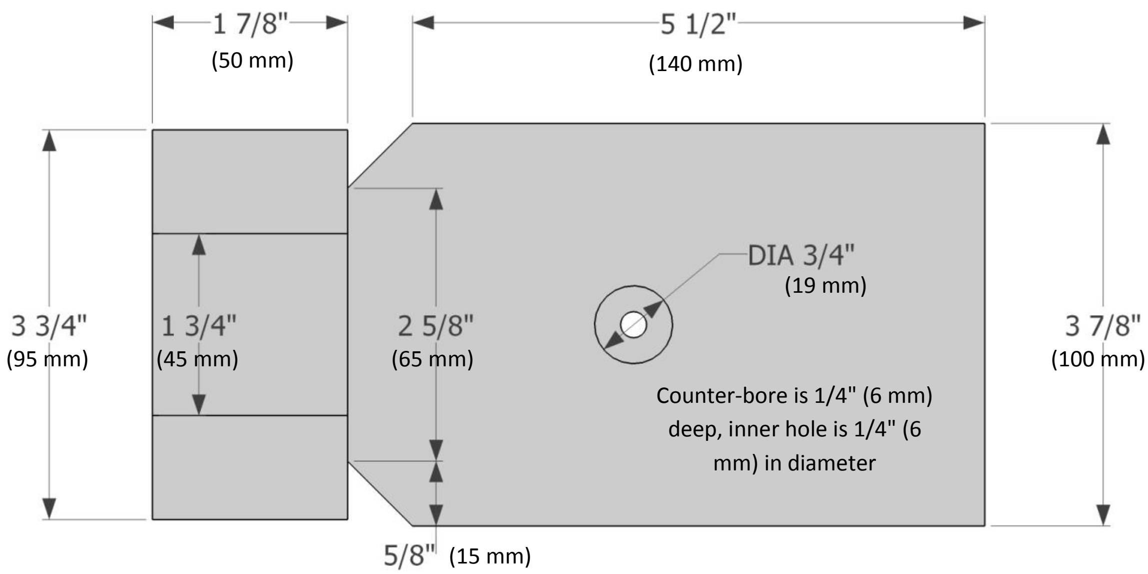


Figure 33: Upper Slides Top View

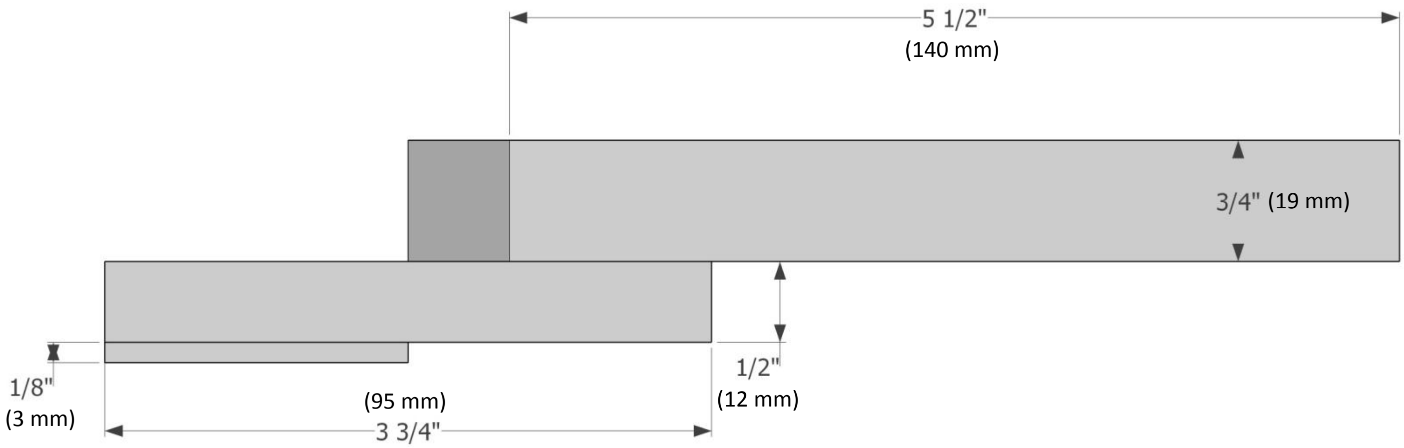


Figure 34: Upper Slide Side View

13. Star Mechanism

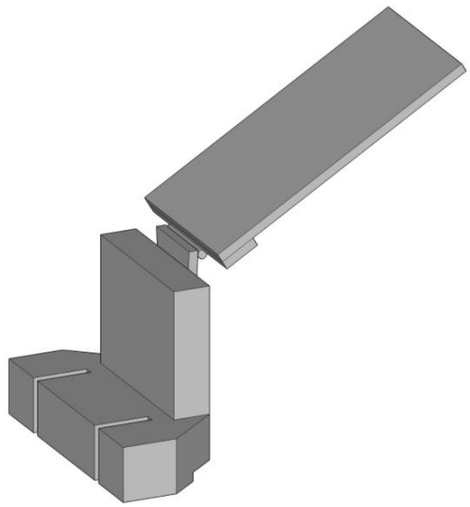


Figure 35: Star Mechanism Iso View

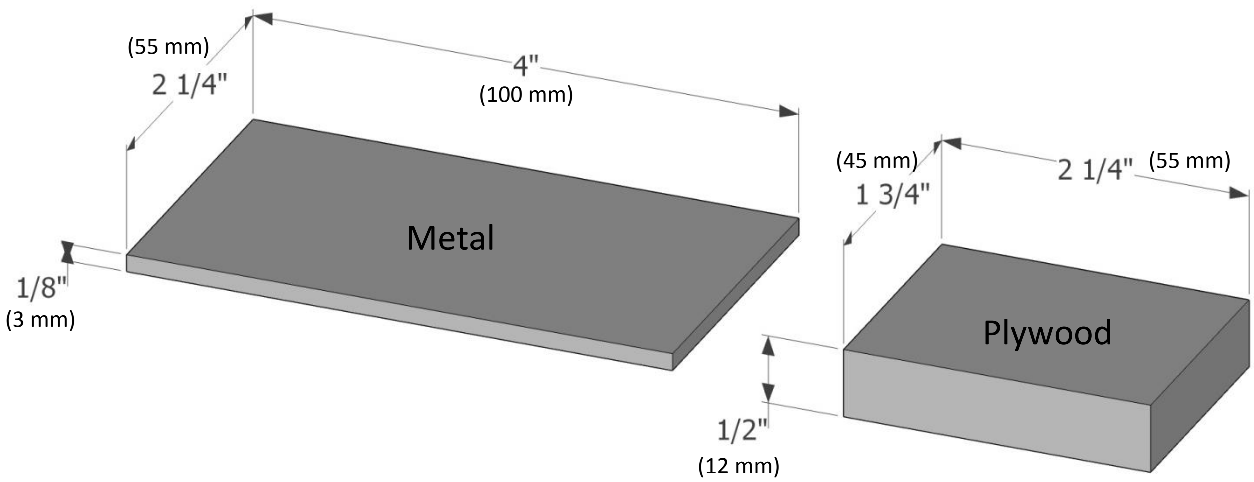


Figure 36: Star Mechanism Side View 1

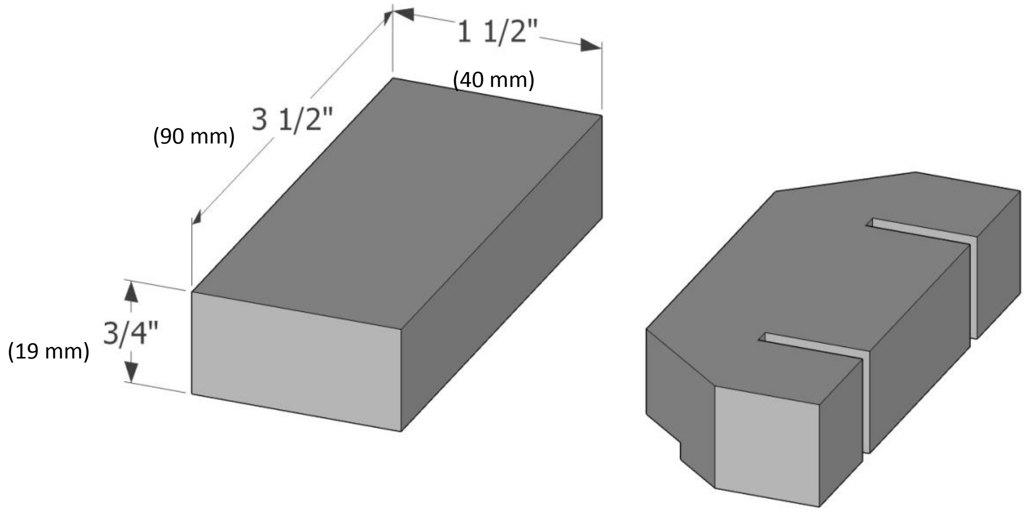


Figure 37: Star Mechanism Side View 2, both plywood

Figure 38: Star Hinge Example, Roughly 2-1/4 x 3-1/2 inches (55 x 90 mm)

14. Main Surface

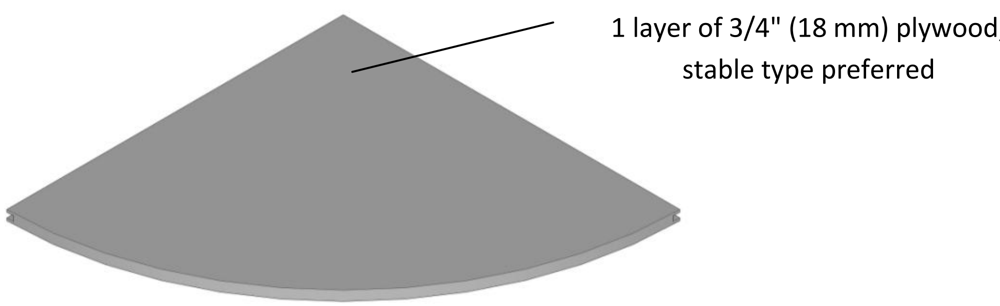


Figure 39: Main Surface Iso View

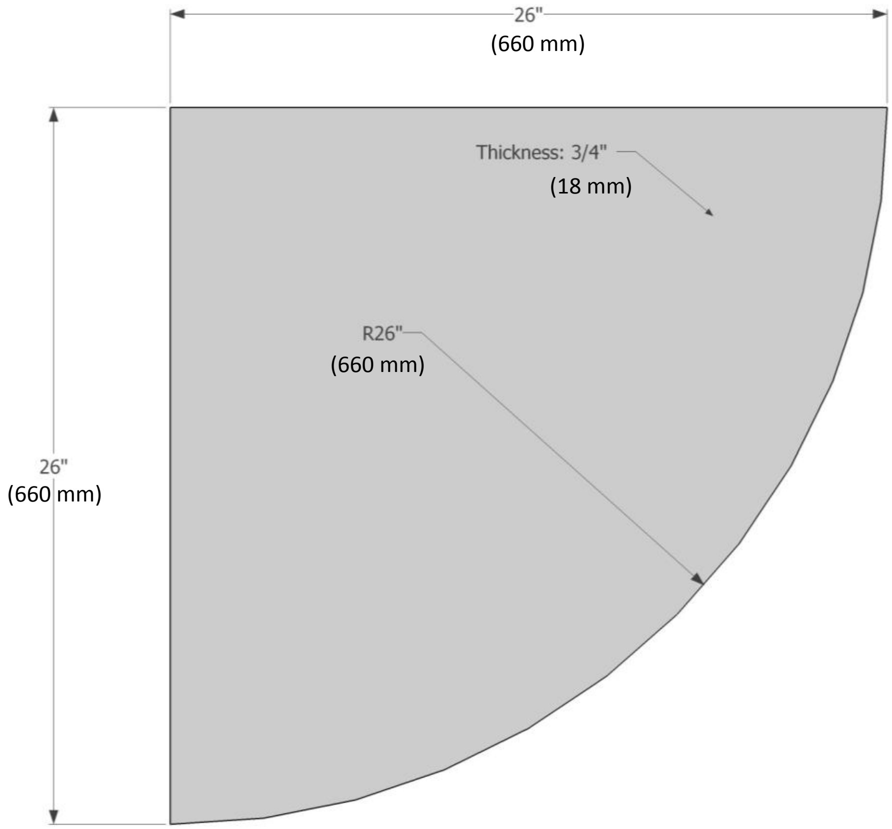


Figure 40: Main Surface Top View

15. Raising Surface

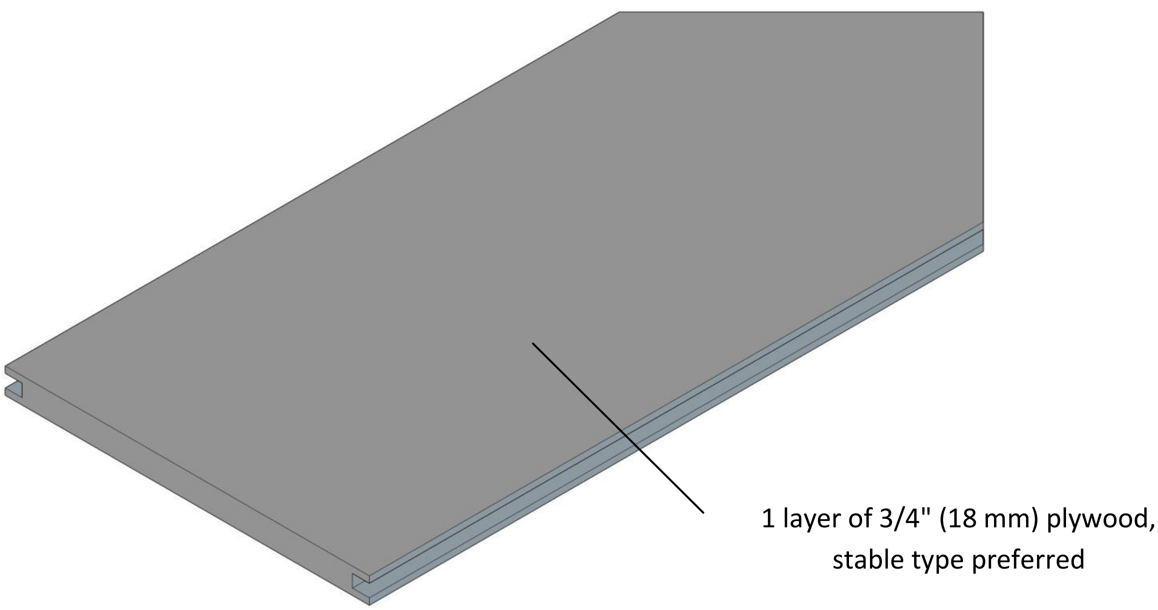


Figure 41: Raising Surface Iso View

Figure 42: Raising Surface Top View

16. Center Star

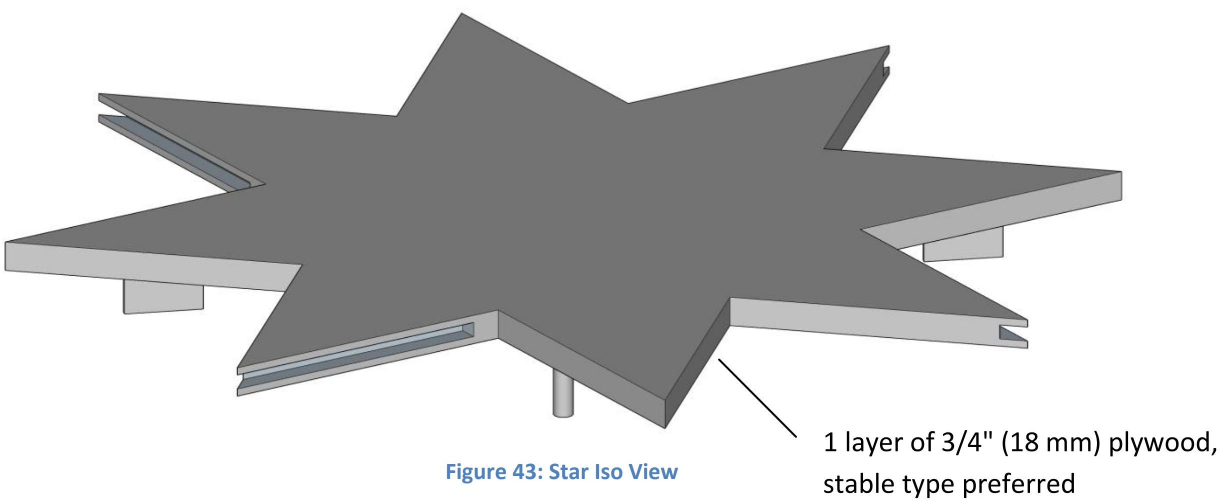


Figure 43: Star Iso View

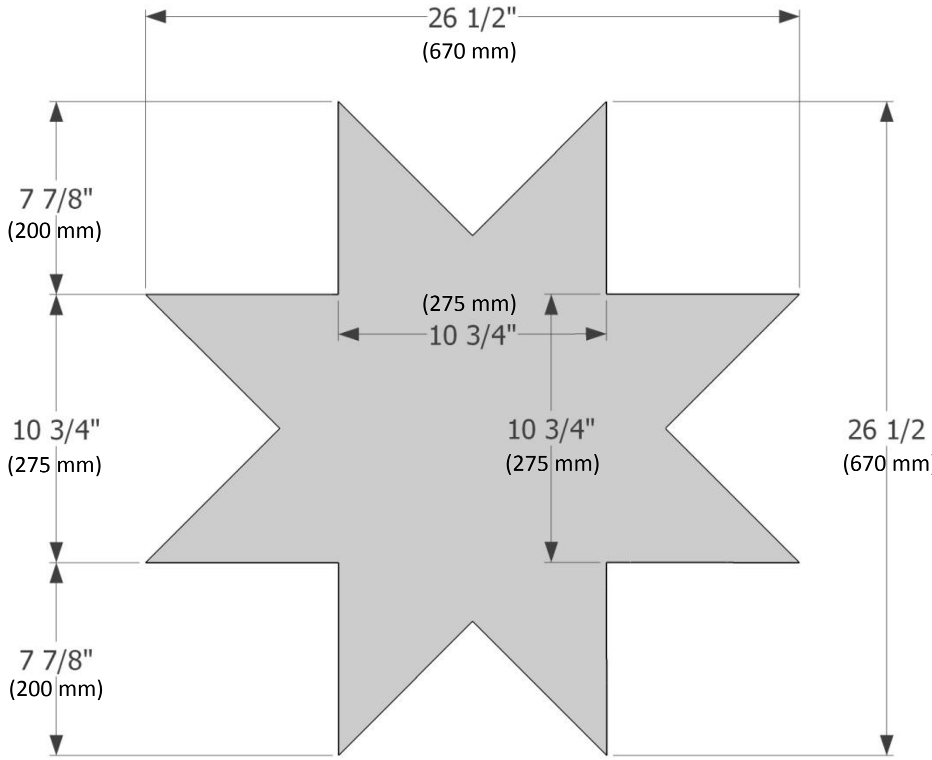


Figure 44: Star Top View

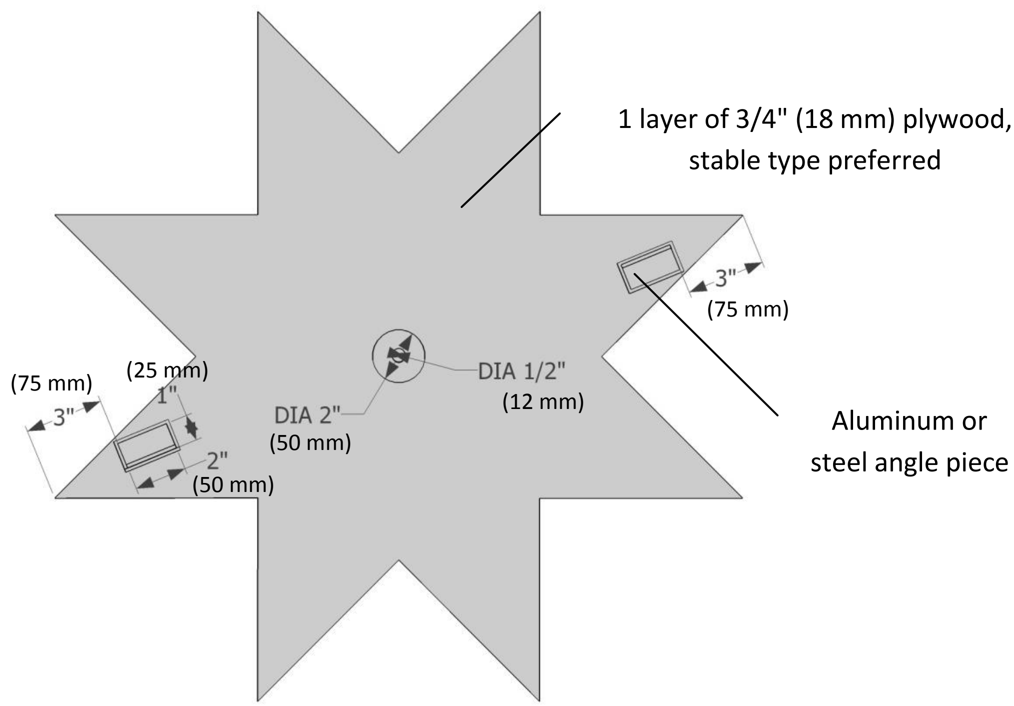


Figure 45: Star Bottom View

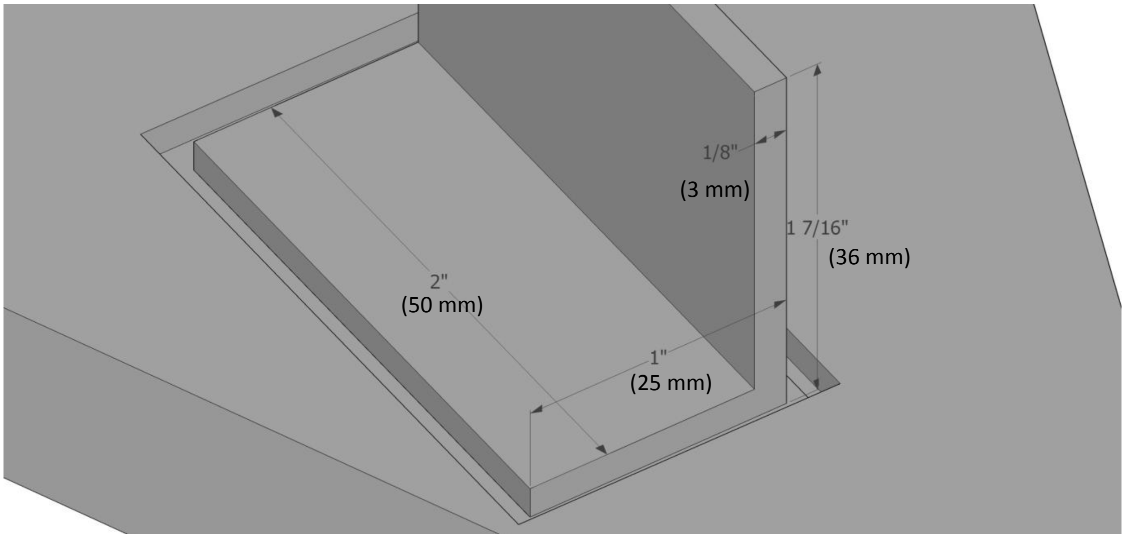


Figure 46: Star Bottom View Angle Detail Iso

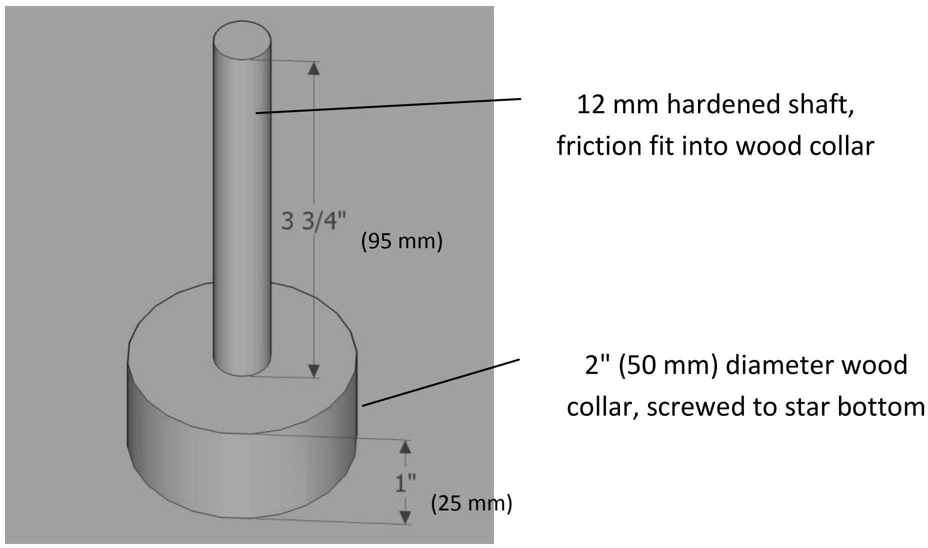


Figure 47: Star Bottom View Center Detail Iso

17. Skirt

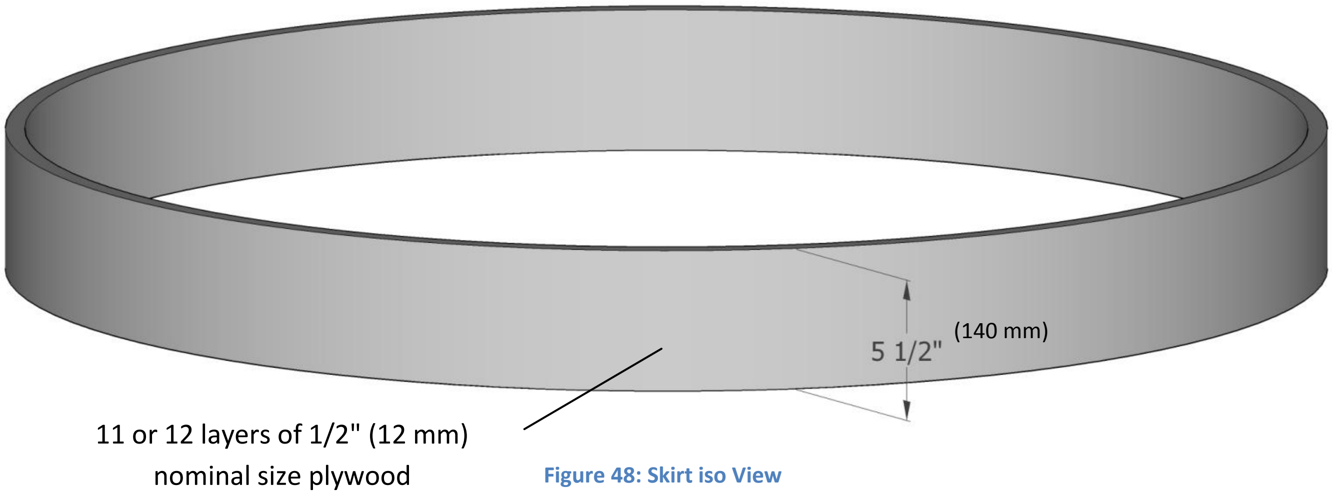


Figure 48: Skirt iso View

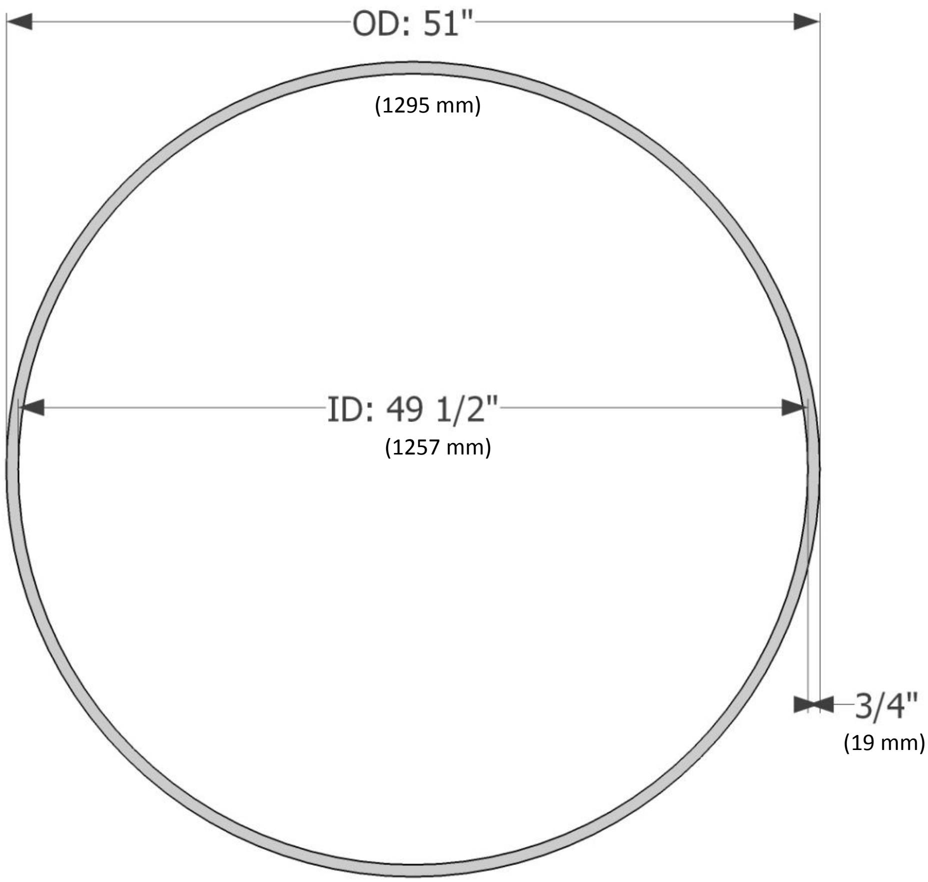


Figure 49: Skirt Top View

18. Dado Detail

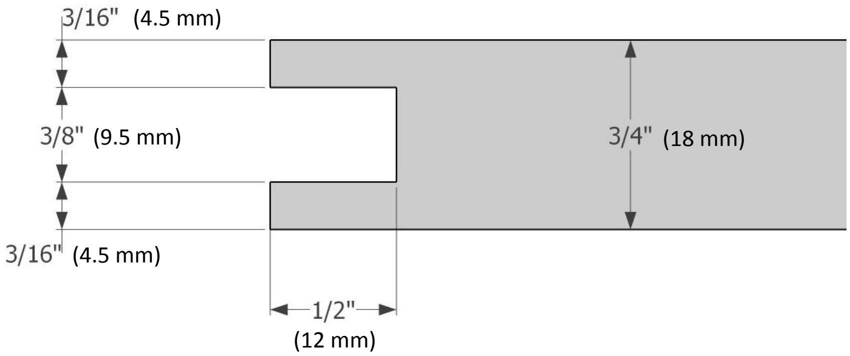


Figure 50: Dado Detail

19. Retractable Roller: Outer Wheel Configuration

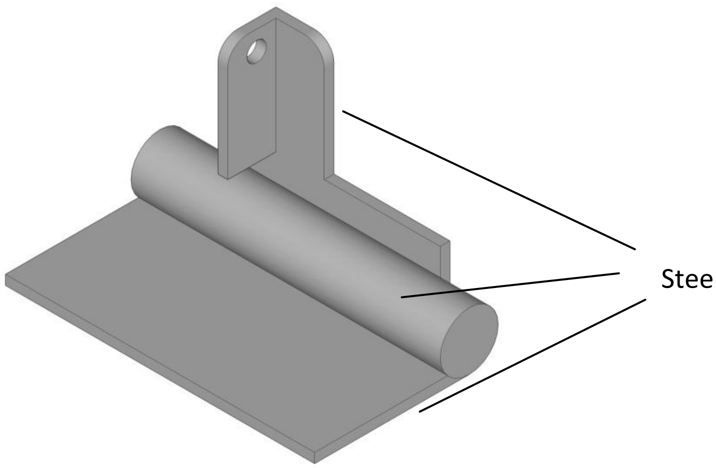


Figure 51: Retractable Roller Iso View

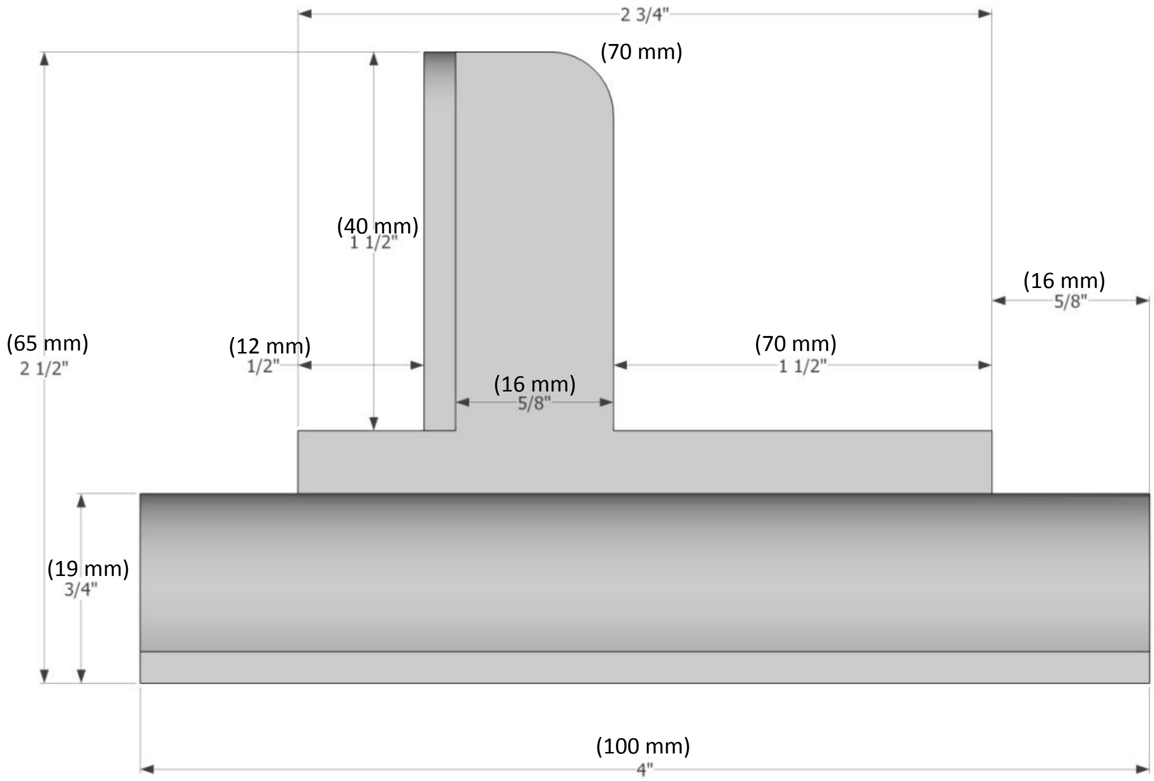


Figure 52: Retractable Roller Front View

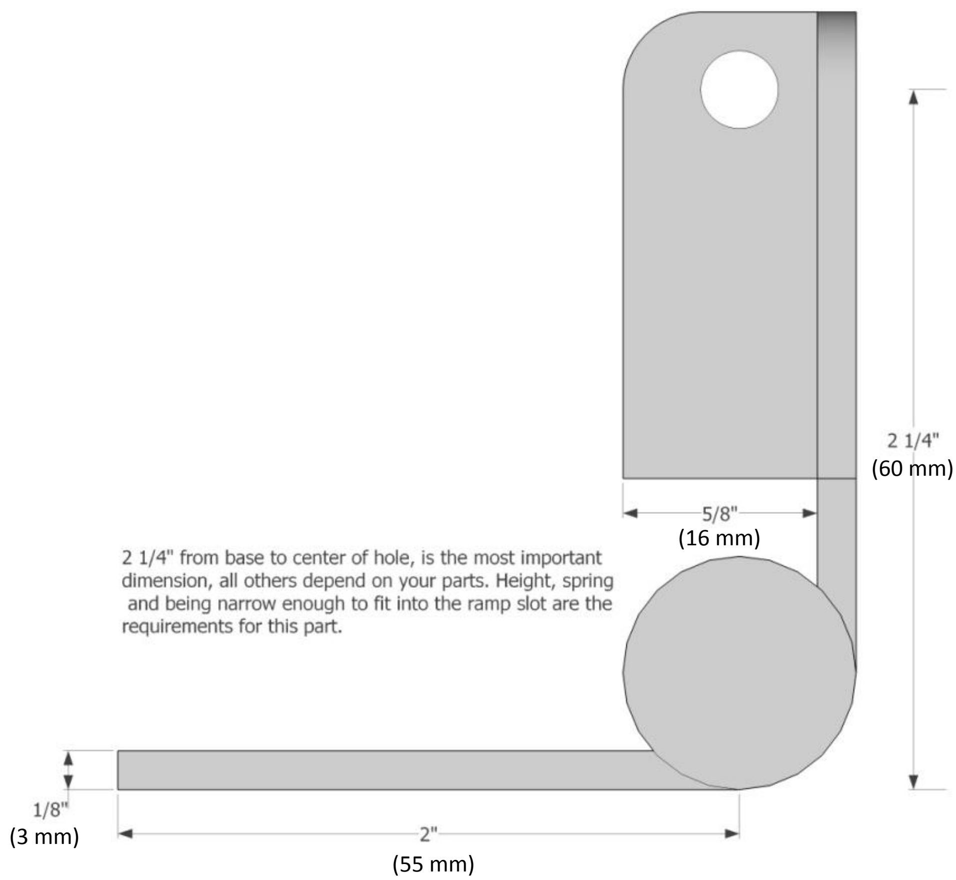


Figure 53: Retractable Roller Side View

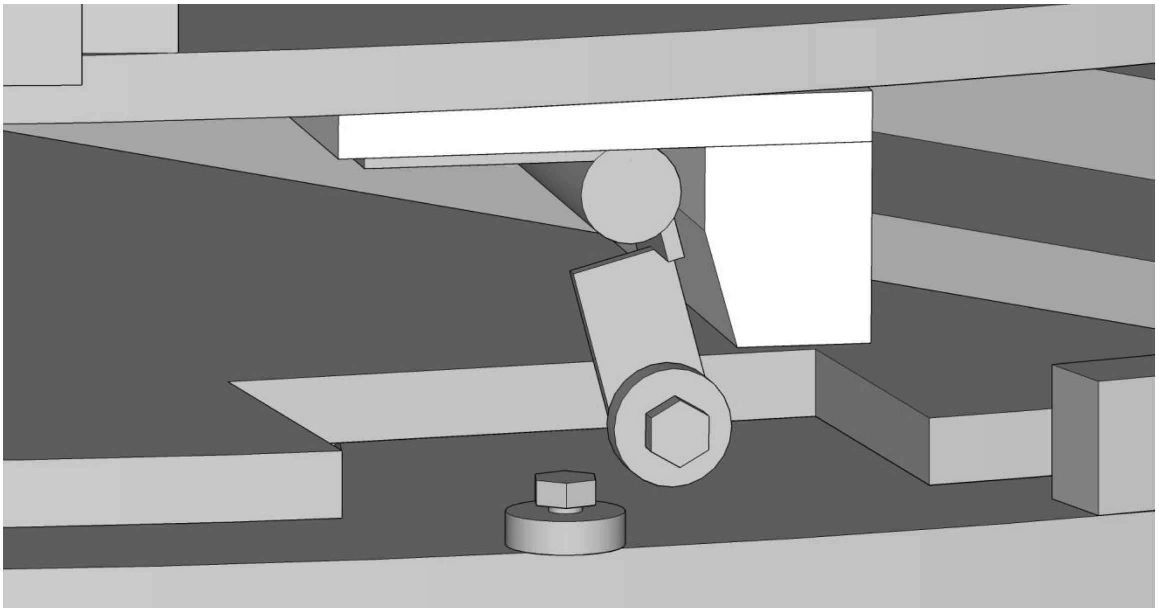


Figure 54: Roller Block Close-up, highlighted in white

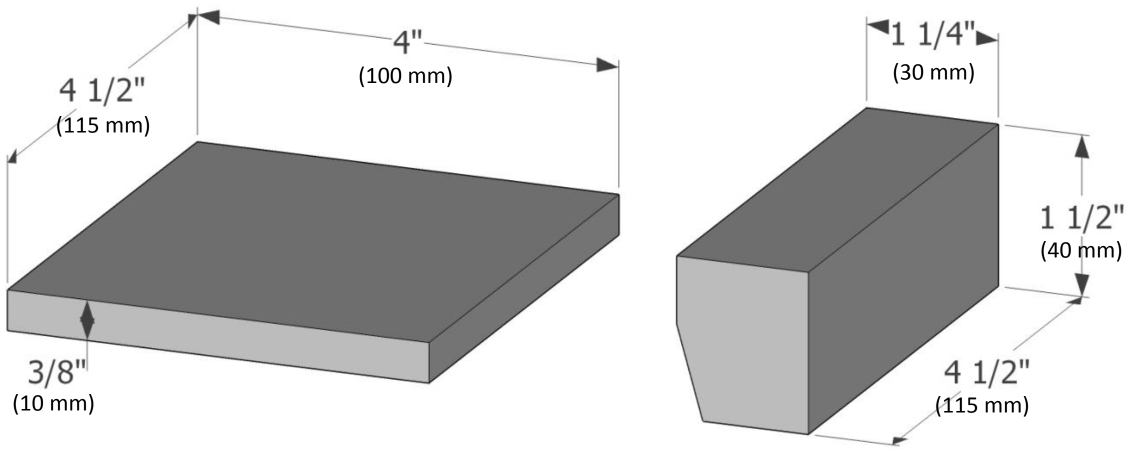


Figure 55: Roller Block Components

Component Notes

1. Legs

The legs were built to be functional, not beautiful. Support level flatness is crucial, as is maintaining adequate leg room and stability. A square leg framing system would leave a pitifully small amount of leg "depth", while a simple X would not be rigid, thus the reinforced X pattern you see. The long X pieces are notched in the center to overlap each other.

2. Support Level

2 pieces of 50" x 50" x 1/2" (1270 x 1270 x 12 mm) plywood were glued together to create this piece. A roller or "ink brayer" is helpful for spreading the glue quickly and evenly. For clamping, I stacked various heavy objects atop the two layers. 1" (25 mm) plywood is available, though gluing two 1/2" (12 mm) pieces together has the benefit of allowing you to evaluate how they are warped/bowed/etc and glue them in opposing directions to cancel it out.

I recommend rough cutting the exterior with a jigsaw and then finishing with a router and trammel. Perfect circularity is not technically required but the closer the better as it reduces interference with the skirt.

The center depression depth is determined by the thickness of your lazy susan. The depression depth is 1/8" (3 mm) less than the lazy susan thickness. This ensures that the lazy susan protrudes above the Support Level surface by 1/8" (3 mm) and connects to the Lower Level. I created this depression with a router and a 3/4" (18 mm) double flute straight bit by plunging in the center and working my way out in concentric circles.

I used car wax to thoroughly coat the surface and reduce rotational friction. The center hole is to accommodate the star's center shaft.

All ramp slots are not identical! The interior slots are wider and go through the table. Exterior slots are not full depth and are narrower. The best strategy here is to build a mortise jig, i.e. an opening the same size as desired, for use with a top bearing mortise bit. This jig can be sized for the interior ramp slots, used fully in that capacity and then simply overhang the edge when routing the outer ramp slots to make them flush.

While their distance from the center may vary, all ramp slots, shelves and drop slots should be 90 degrees from one another. The angular orientation of skirt ramps to other ramps is not critical, I would orient them approximately as shown in the diagram for ease of troubleshooting later (better line-of-sight). The same strategy applies to the skirt XY bearings.

As seen below, the skirt ramps have an "extension" which ends in a stop block. The extension is 1/4" (6 mm) thick and wide enough to stay under the skirt's roller. Rather than cutting the piece to fit the level's radius I would simply let it overhang and use the trammel to cut it flush. The stop block should be roughly 1" high (25 mm) , 3/4" wide (19 mm) and 1.5" (40 mm) long. The drop slot should be no closer than 5" (130 mm) from the end of the ramp slot.

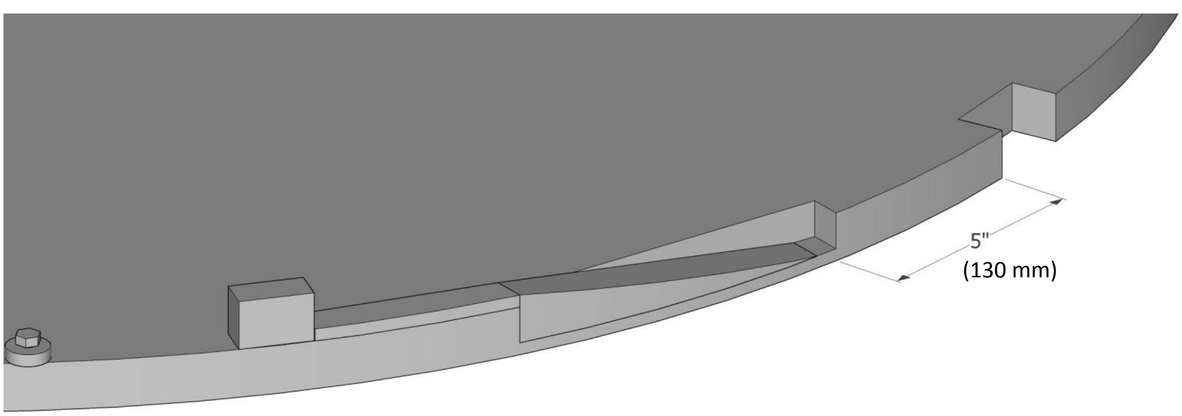


Figure 56: Skirt Ramp Closeup

The skirt XY bolts shown below should be attached after fabricating the skirt. They consist of a bolt and skateboard bearing combination with a washer between the bearing and support level surface. The bearing should spin freely. The nut on the bottom should be counterbored to prevent interference with a person's legs.

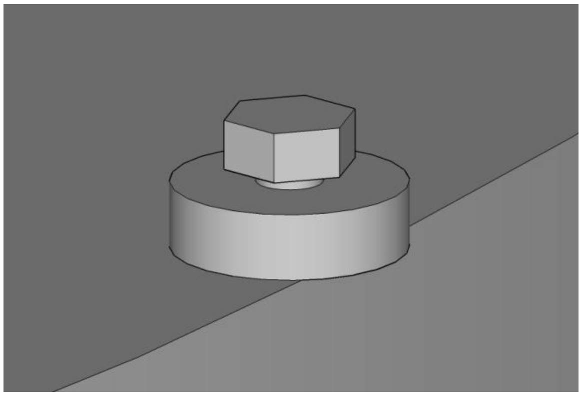


Figure 57: Skirt XY (Horizontal) Plane Bearing Closeup

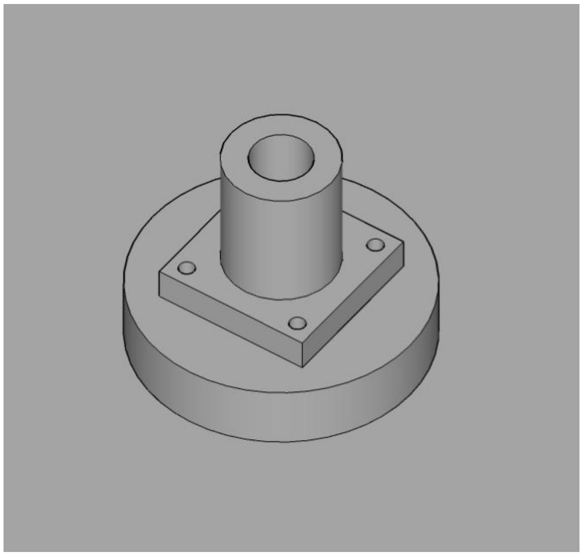


Figure 58: Star Center Bearing Closeup

3. Ramps: Wide & Narrow

The table rotates about 170° when going from closed to open positions. This means that the ramps must be staggered radially to prevent the roller from falling into its "neighbor" ramp's slot.

The ramps are 1" (25 mm) in height, this derives from the surface panel thickness, 3/4" + 1/4" (19 mm + 6 mm) for clearance. They have two widths: 1-3/4" for the interior ramps and 1" for the skirt ramps.

Ramps are glued into place. The exterior skirt ramps are easiest as they have a "shelf" to sit on. Interior ramps will probably require a temporary bottom to hold them at the correct height while the glue on the side dries. These temporary supports could be waxed or covered with waxed paper to prevent gluing them in place as well.

At the low end of the ramp area there will be a 1" (25 mm) space, this is to let the flip down and lock into place before rising. The ramps and their spaces are all at 90° to one another, in my design the legs are also at 90°. If you attach the support level to the legs in the correct orientation all spaces should be concealed by the leg framing.

4. Lower Level

This level is fairly straightforward, a jig saw and 1/8" (3 mm) tolerance should be sufficient for all major penetrations. Slide alignment is critical but we'll save our energy and precision for the actual slide *guide* alignment. Guide attachment described in its own section below.

The pieces on the bottom are there to transfer weight to the Support Level while minimizing surface area, they are glued into place and also waxed on the bottom. UHMW tape or other friction reducing materials are also helpful on these pieces.

Components/openings are oriented on 30 degree intervals, as shown in Figure 9.

5. Linear Slides

The Upper Level needs to rotate in sync with the lower level while remaining free to raise. To accomplish this I used inexpensive linear slides with hardened steel rods. (Note: unless you have achieved perfect symmetry, unlikely, this is the point where your two levels will be coupled in a particular orientation, i.e. they will go together this way but not if one is rotated 90, 180 or 270 degrees.)

The slides are mounted to the bottom of the upper level. Make the Upper Level hole oversized (5/8" (16 mm) for a 12mm rod) to prevent binding. The hardened rods are mounted perpendicularly into square steel plates and welded on the bottom. Welding on top would prevent the linear bearing from settling all the way down. The steel plates should be wide enough to provide stability and prevent binding. It also allows you to shim, if necessary, to make the linear rod perpendicular to the lower level. Welding has a habit of distorting pieces as they cool, so this adjustability is helpful.

An alternative to welding: JB Weld or similar epoxy could be used if the shaft were roughed up with an angle grinder. The shaft could then be epoxied into a slightly over-size hole and braced in the correct vertical orientation while it cures.

6. Lower Stiffeners

I considered making all four of these pieces out of a single sheet, but I do not believe it would have significantly reduced the flexibility, while it would certainly make the material use less efficient. In my case, Baltic birch plywood comes in 5'x5' (1500 x 1500 mm) sheets, so I was able to use a 4'x4' (1200 x 1200 mm) square for the levels and the remaining 12" (305 mm) pieces for components like these stiffeners. They are glued into place.

7. Lower Slides

The slides need to be as stable as possible. While I'm sure there is a foreign wood that inherently meets the criteria, I chose ash for the main components and hard maple for the connection piece due to its stiffness.

The ash has been ripped and glued up to create a piece free of knots and with relatively uniform grain. Expansion horizontally will bind the slide guides, so I oriented the grain vertically.

It's best to run your screws in from above for ease of assembly, the picture below illustrates what NOT to do, as this requires you to unscrew them from below every time. I learned my lesson on the top slides but haven't converted the bottom ones yet. Note that this is from a previous version of the table and slides are now shorter.

Figure 59: Slide Grain Detail

The spacer blocks (Figure 18) should be constructed of stacked plywood, regular wood will change shape too much and any issues here are multiplied at the ends of the surface panels.

8. Supports

These components support the main surface panels that will bear the majority of the weight. The top main panels are quite a bit wider than their slides so this surface provides two main benefits: wider surface for shimming and increased upper layer stiffness.

9. Octagon

This is where the magic happens. This mounts directly to the support level, on top of the lower level lazy susan. The orientation of this piece relative to the raising ramps must be correct to ensure that the lower level rises when the table is at its most expanded point. Fortunately, this is easy to adjust and "pretty good" during the initial construction is fine. Once your rollers and ramps are finalized you can get everything moving in sync.

Note: the arms for the upper slides mount to the bottom of the octagon's top piece and must be attached before placing the octagon into the center.

10. Arms

These were cut with a jigsaw from 1/8" (3 mm) steel plate. The arms were originally in the same plane (i.e. all mounted on top of the octagon) and thus had to fold together very carefully, as this is no longer the case I suspect that a simpler shape may suffice, but mine functions well as is. Be sure to file or otherwise knock down the sharp edges on freshly cut pieces, not only will they hurt you, but they are more likely to catch on wood pieces in the table and jam.

The arms attach to the octagon with simple pan head wood screws. I recommend using a screw that is "too long" and trimming the excess with an angle grinder.

To attach the arms to the main slides I recommend shoulder screws (example in Figure 60). Threaded screws will work fine for a while but eventually the threads wear down and create slop in the system. Tighten them all the way down and then back off 1/8 to 1/4 turn, just enough to make it free. You should then test the arm's freedom of motion both in and between the closed and expanded positions.

Figure 60: Shoulder Screw Comparison

The upper sliders are unique because they are higher and then rise further still. I settled on bolts extending down until they reach and thread into the arms. This requires you to tap the arm pilot holes, but at 1/8" (3 mm) thick even an inexpensive tap will be fine. Threads in the arm also allow you to very easily adjust the arm height. In order to prevent this bolt from loosening over time, I recommend using a nylon locknut to lock it into place. Figure 61 illustrates this idea.

General tip: When cutting off the excess bolt length it is handy to first thread a nut onto the bolt. After cutting you can back the nut off and it will clear and straighten the threads with minimal effort. Also note that using an angle grinder next to a nylon locknut may overheat and ruin the nylon, keep a few extras on hand.

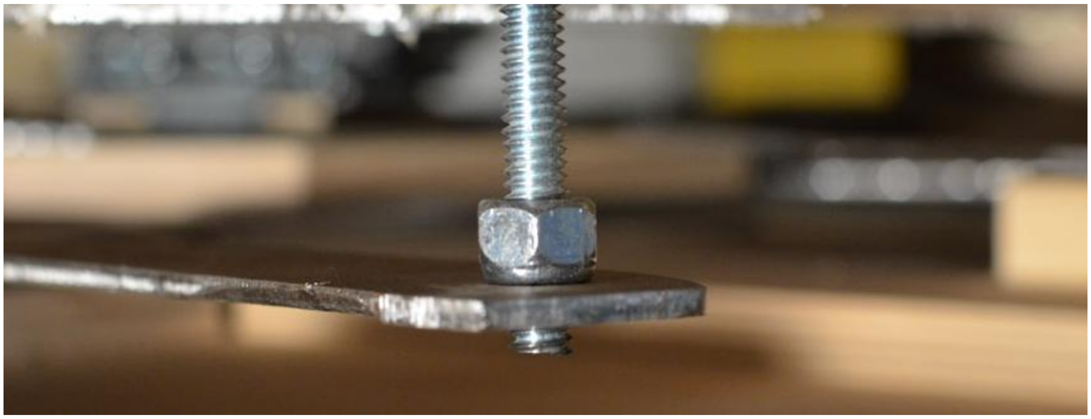


Figure 61: Arm Connection Photo

11. Upper Level

Tolerances are the same as its lower counterpart. This level does not have stiffeners for two reasons: it bears less weight and it has room below for the bottom of the slider. Guide attachment described below.

The center depression depth should equal the thickness of your star mechanism levers. The purpose of this depression is to keep your levers at the same height (in the lowered position) as the rest of the upper level. It is helpful to route or profile the interior circle as this is where the three levers rest, I found a 1/4" (6 mm) round over bit to be ideal. Figure 63 is a detail photo of this area.

Angle's between "like features" (example: the long thin slots or linear bearing holes) are still 90 degrees, as shown in Figure 31.

12. Upper Slides

Same notes as lower slides, but with their respective dimensions.

13. Star Mechanism

I recommend watching this video, beginning at 7:25 to see it in action: https://www.youtube.com/watch?v=7JFJSIJIe9A

In the collapsed/small state, the table's surface panels are at 3 different heights. The main surface is always exposed, the raising panels are below and the star is on the bottom. Since the height of the main surface does not change, the raising level must rise by one thickness while the star must rise by two.

Ramps are impractical as space is limited in the table center, I used a lever system instead. When the Upper Level rises 1" (25 mm), the lever multiplies this into a 2" (50 mm) rise at its end. That end rests under the star. The star must also maintain its rotational alignment with the other surface pieces, that's the purpose of the 90° aluminum pieces extending down. They are attached in depressions routed about 1/8" (3 mm) deep into the surface so they do not make the star thicker, thus sitting too high and interfering with the other panels.

Figure 62: Star Bottom View Photo

The single linear bearing in the center of the support level is best mounted on a piece of 1/2" (12 mm) plywood, this brings it up (increasing star stability) and it gives you more freedom in adjusting it to find the exact table center.

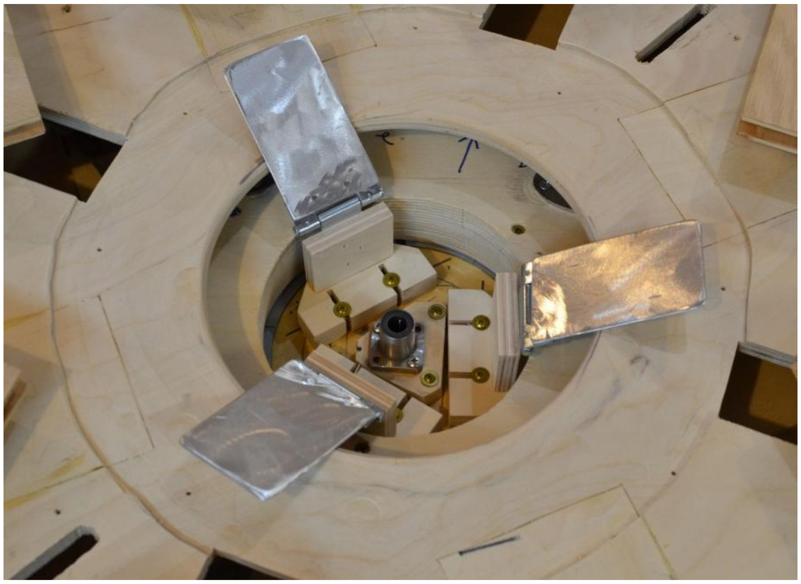


Figure 63: Star Mechanism Photo

The mechanism in Figure 35 is simpler than it may appear. Figure 36 shows the metal and vertical wood components. The precise size of slots and shape of the horizontal part are not critical, the general block shown at left in Figure 37 can simply have a few slots added and the corners mitered to fit into the center area of the table. The small rabbet or notch on the mitered side is simply to clear the lazy susan inner flange, if applicable in your case. The hinge used is just a standard hinge of medium size (Figure 38). I recommend using sheet metal screws to mount the metal part and simply trimming the excess with an angle grinder.

14. Main Surface

I used 3/4" (18 mm) Oak veneer plywood due to my experience with its stability.

I used a flush trim router to cut out my shape: http://youtu.be/0McJLOMpDqo?t=1m9s A rough cut with a jig saw and final with a router trammel would probably be easier and more accurate.

Squareness is vital here. Any error will be multiplied across the four panels, so even a 1/32" (0.8 mm) error becomes 1/8" (3 mm). Making three panels and compensating with the fourth is also a poor strategy as it means you will again have to compensate for *this* compensation when fitting the raising panels and center star. With a good framing square, large sheets of paper for verification and very careful marks I was able to limit my total error to about 0.04 (1 mm) inches.

Dado cuts are fairly easy on the straight sections. The tongues (Figure 64) were made from scrap wood and beveled with a hand plane.

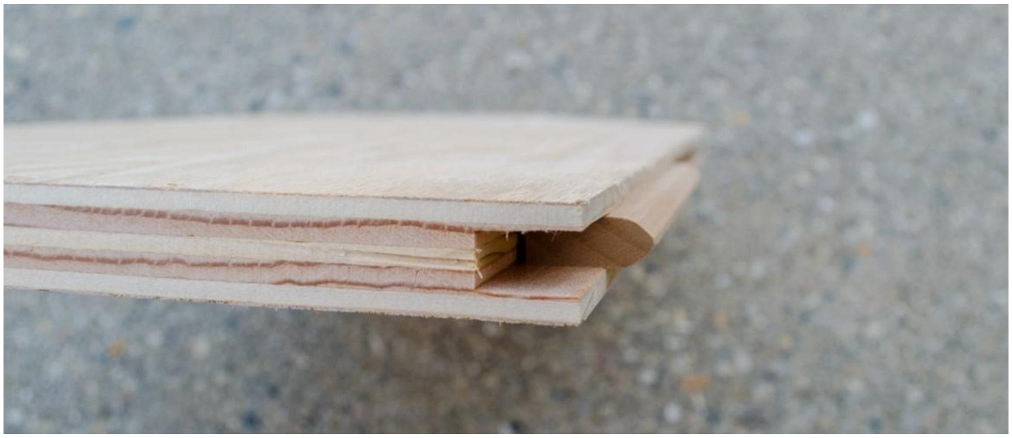


Figure 64: Dado and Tongue Detail

15. Raising Surface

These are easy to cut on the table saw, I used a miter sled for the angles and a custom sled to safely dado the short front surfaces.

16. Star

Due to the numerous possible adjustments and small differences, I recommend cutting the star to fit if you are doing the other work by hand. If you are using a CNC machine the vector files should work fine.

To cut it by hand: I created a pattern by placing a taut sheet of paper over the expanded table and making a rubbing with a crayon. You do not need to record every crack and crevice perfectly, only a good representation of the lines, which can then be extended to their intersections.

As for cutting out the star, patience is my current solution. A test piece never hurts either, before getting into your high quality material. Banding the edges with hardwood, or perhaps making the star itself from an extremely stable hardwood would be best.

Where required, I cut these "dados" with a biscuit joiner and multiple depth settings.

17. Skirt

Bent lamination is not recommended to construct the skirt, the size needs to be very consistent to prevent binding and spring-back is a major concern. Figure 65 shows the dimensions for a 1/6 (60 degree) section of the ring. This piece already includes extra thickness in all directions. In order to achieve a smooth exterior surface I recommend building up the ring (if you're using 1/2" (12 mm) plywood) 4 lifts at a time. This allows you to use a regular vertical router trammel with a single bit to cut the inside. This can be used on the outside as well but gluing the lifts together will result in some variation. Routing the outside close, but not completely, then gluing together and oriented the router perpendicular to the outer surface would give the best finish. This would require a significantly more elaborate trammel setup.

Elevator bolts were used to mount the bearings (Figure 66). Nylon locknuts are again recommended. This allows you to veneer over the surface for a smooth finish, if desired. To rotate the ring I added 8 thin vertical strips so they wouldn't extend out past the top surface. There are many options though.

If the placement of your XY bearings need adjustment consider wrapping them in foil duct tape to increase their diameter, this is much easier than trying to shift the bolt. The bolt will also need to be mounted very close to the edge, if a larger bearing could be used to help this though I had no issue being close to the edge as any forces on the bolt point inwards.

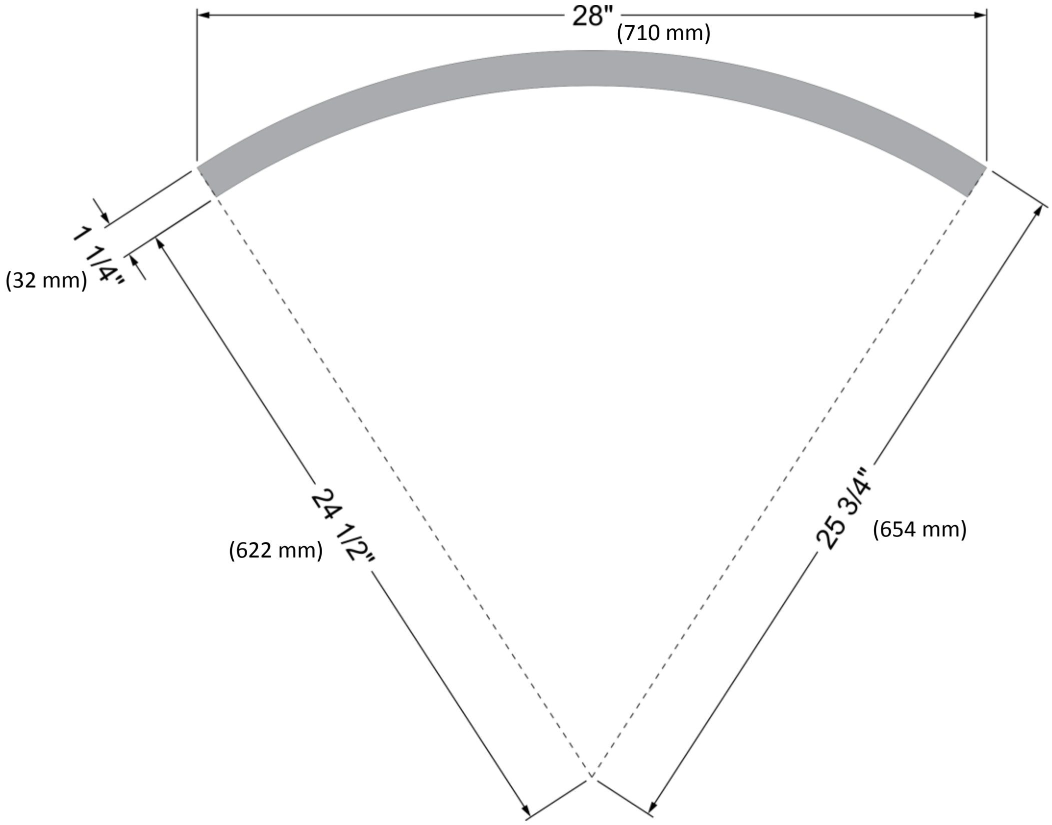


Figure 65: Skirt Section Pattern

Figure 66: Elevator Bolt

Figure 67: Bolt Head Comparison

Figure 68: Skirt Roller/Bearing Closeup

18. Dado Detail

Required on the mating faces between surface panels, and on every other corner of the star.

Figure 69: Star Dado Detail

19. Retractable Rollers

Figure 70: Roller Open Detail

Figure 71: Roller Closed Detail

To understand the motion of this piece please view this first: http://youtu.be/XB3p6pCay4w?t=20s

The folding function is required to help minimize the overall table depth. If it were not retracted most of the time, the ramp depression would have to extend as a slot much further (to accommodate the wheel in the lower position), multiply this feature by four and you have severely weakened the support level.

The hinges are from Home Depot in the US, store code #526504
Figure 72 shows one prior to modification.

Figure 72: Stock Hinge

I used an angle grinder, hacksaw and vice to achieve the current shape, Figure 70 and Figure 71. Make sure that the ball bearing (size 8x22x7 mm in this case, which happens to correspond nicely with 1/4" (6 mm) diameter bolts) is free to contact the "ground" in the open and folded positions.

The wooden block serves two purposes. First: it allows the hinge to open only to a certain point, thus providing some adjustability as to the height in the open position. Second: it allows the upper level to rest directly on the lower level in the lower/closed position. This is illustrated most clearly in the video listed above. The angle on the face must be adjusted according to your individual machine, the one shown in Figure 54 and Figure 55 are just approximations. The 3/8" plate shown at left in Figure 55 may or may not be necessary depending on your particular mechanism and hinge.

The open angle and exact position of these hinges must be adjusted so that their raised height and the point at which they begin rising are all synchronized. If one roller meets its ramp before (or after) the other's it will begin to twist the upper level and cause binding on the linear slides.

These pieces come in two configurations, one with the wheel offset to the outside and another toward the center to accommodate the inside raising ramps. The offsets and exact dimensions depend on your situation, so these adjustments will need to be determined by you, and should not be difficult since I've specified the ramp locations.

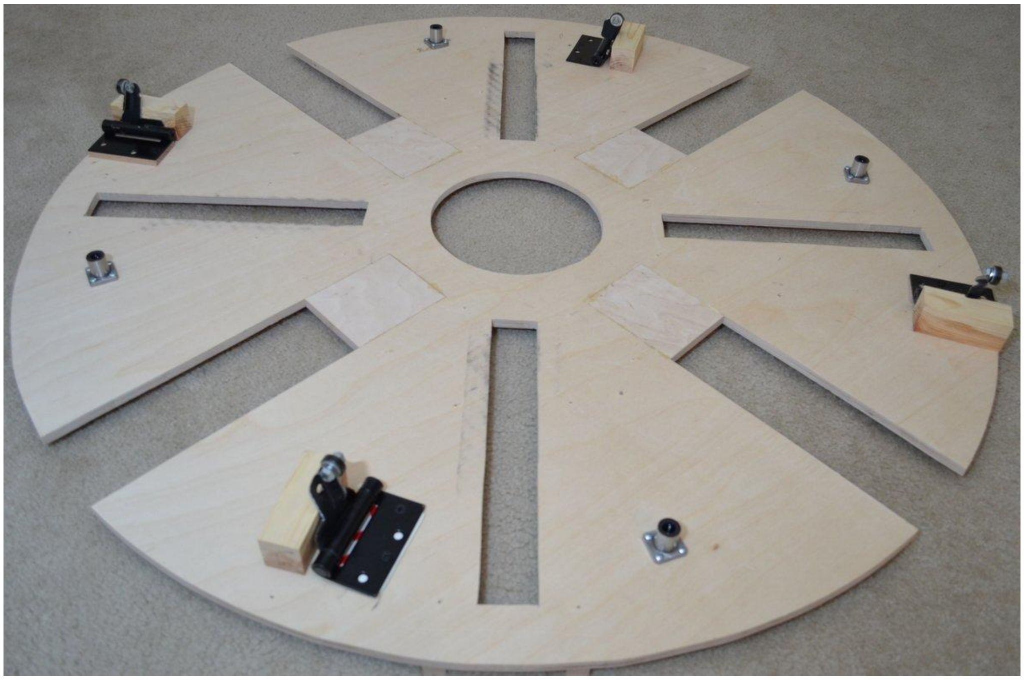


Figure 73: Roller Style Detail

Figure 74: Roller Center Detail

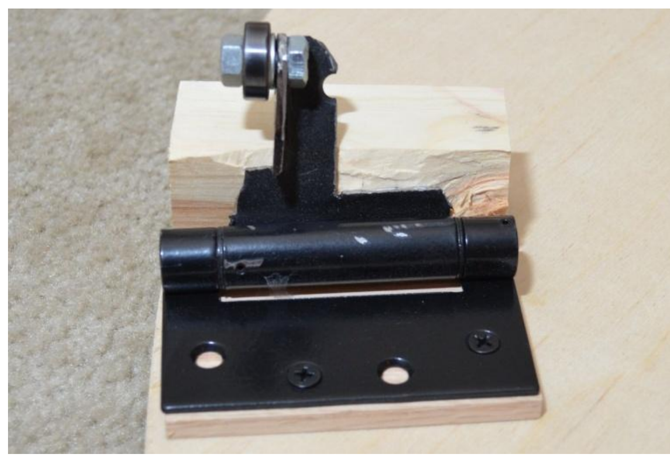


Figure 75: Roller Offset Detail

20. Slide Guide Alignment

For this important task I recommend establishing centerlines first and lightly clamping the guides into their tentative locations. The alignment can then be verified with a long straightedge (a 6' (1800 mm) level in my case.)

After fastening one side of the guides, place 2 or 3 playing cards between it and the slide, then press the opposite slide against this assembly and fasten it down. This establishes the location of the opposite slide and, upon card removal, leaves a consistent amount of play. I employ this sort of "mechanical measuring" whenever possible.

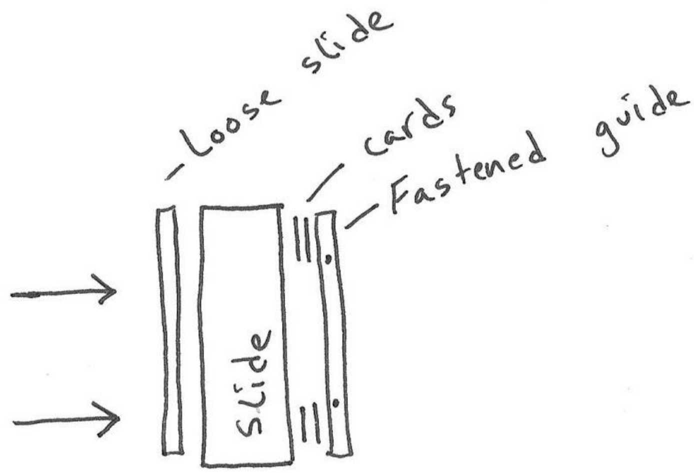


Figure 76: Slide Guide Alignment

General Notes

- **Flexibility:** Everything flexes/bends/deflects under load. Minimizing the table thickness was complicated by my desire to also minimize deflection. The easiest way to minimize deflection in a material under vertical load is to increase the vertical depth, precisely the opposite of what I was trying to achieve. This design is the best compromise I could formulate.

- **Numbering System:** Establish a single numbering system for panels, sliders and other components at the beginning of the project. Ink/marker is recommend over pencil, you will likely be handling these parts quite a bit and pencil smudges, particularly if it's an area that gets waxed.

- **Shimming Surface Panels:** Pan head screws make great shims when adjusting multiple pieces into alignment. Rather than stacking shims below a panel, for example. You use 3 screws driven nearly all the way in (may require countersinking) and simply adjust their height with a screwdriver. This has the advantage of being very quick and low frustration, screws won't flutter away or get bumped out of location. While screws may not be as good for bearing large loads, in this case they can be used to quickly determine the correct height. This height is then matched by hard shims.

- **Metal Sheet Layout:** Figure 77 shows a suggested layout for maximizing your use of a metal sheet when creating the arms and slide bottoms.

1/8" (3 mm) Metal Sheet Suggested Layout

16 x 24 inch (410 x 610 mm) Minimum Dimensions

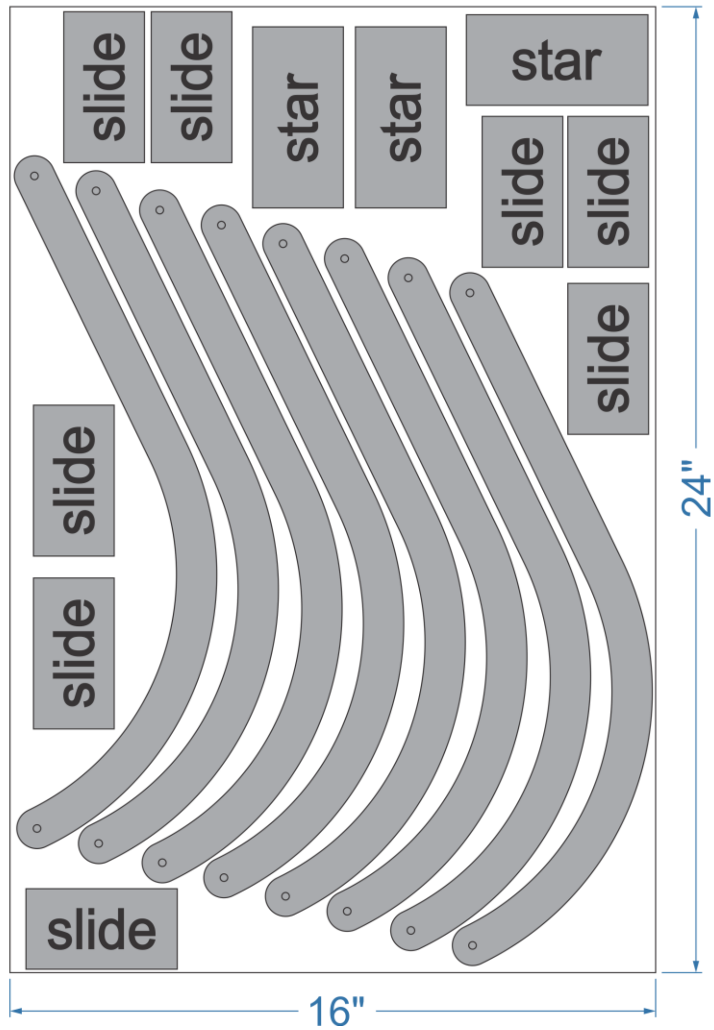


Figure 77: Suggested Metal Sheet Layout

- **Friction Reduction:** I tried using UHMW (low friction) tape in a few places to make the table easier to rotate. After some experimentation, I settled on the following combination for the slides: tape on the bottom of the slide itself, one piece on each side, and tape on the top of the "tail" piece which extends under the layer. The areas of wood that the tape slides along should be waxed, I used furniture/car/general paste wax. This combination seemed more effective than tape on both surfaces.

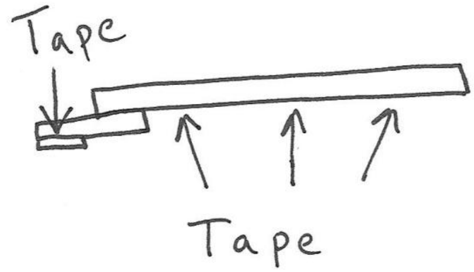


Figure 78: Tape Location Detail Side View

I also tried tape on the bottom of the first level "pads" the 6"x2" piece right under the main sliders, but for some reason this made essentially no difference to the effort required to rotate the table (as measured with a scale.) A very shallow roller system may be the best solution. Of course, if you reduce the friction too much, the table becomes too easy to open or close and requires a locking knob/system.

Link to the product I used: http://www.amazon.com/gp/product/B000REGUE4/

- **Mounting Surface Panels:** Mount the main surface panels first. Slide two of them together, creating a half circle and align them based on the center point of the table and their respective slides. When satisfied with their position, clamp them in place, add the other panels and clamp them in place as well. Expand the table and measure to see if their edges have remained parallel. You should also sight down the edges of the panels to see if they align with their neighbor panel. If the panels are correctly aligned over the table center, but not centered on their slides, you will end up with a (hopefully less exaggerated) version of Figure 79 when expanded.

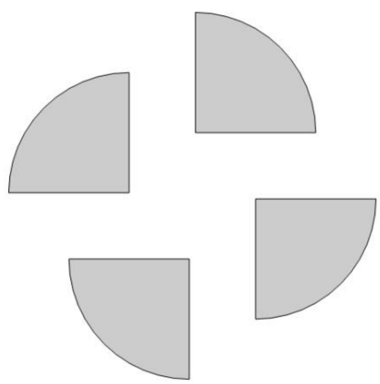


Figure 79: Panel Orientation Error Example

If adjustment is needed I recommend doing the previous steps more or less in reverse order: collapse table, unclamp two, remove two, unclamp remaining, adjust based on error observed in expanded position, re-clamp add other panels, re-clamp and expand. I usually go through at least three cycles of this before I'm satisfied.

Adding the raising panels is, fortunately, much easier. Expand the table until the raising slides have reached their full height and set the raising panels in place, then carefully lock the table into its expanded position, adjusting the raising panels as necessary. When everything is in place, trace the slide's position on the bottom of the raising panel, this will record your progress and allow you to make adjustments described in the next section.

Do not rotate the table into the fully closed position (i.e. until it stops) when establishing your "closed" position for the main surface panels. You need to have a little (maybe 1" (25 mm) at the perimeter of the table) rotation left in the mechanism when the panels come together so you can rotate past this point, take up any play in the system and squeeze the panels together.

Once their location is determined the panels must be fastened into place. This step has become more difficult with the addition of the skirt as the slides barely extend beyond the mechanism. My current best solution is simply to rotate until the slides are at their most extended point (just after the upper level has come up) and fasten upwards at an angle through the slides into their panels. Countersinking these screws is highly recommended as you are close to the slide's end grain and at risk of splitting. Since the screw will likely be driven at an angle the head may protrude slightly below the slide, in this case an angle grinder can be used to grind it flush.

- **Panel Closure Order:** The order in which the panels come together can be a help or a hindrance to smooth operation. When the main surface panels (90° "pie wedges") come together they self-align to a certain degree. When they are coming together in the expanded position, however, if the main panels come in first they can "trap" the raising panels on either side, Figure 80, requiring an external tap to reach their final position. Figure 81 shows the best order, which allows us to take advantage of the pieces' shape.

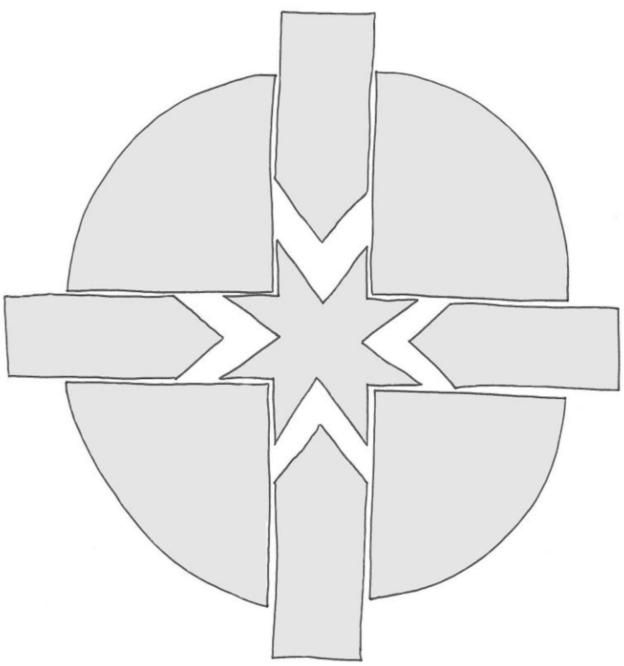


Figure 80: Wrong Order

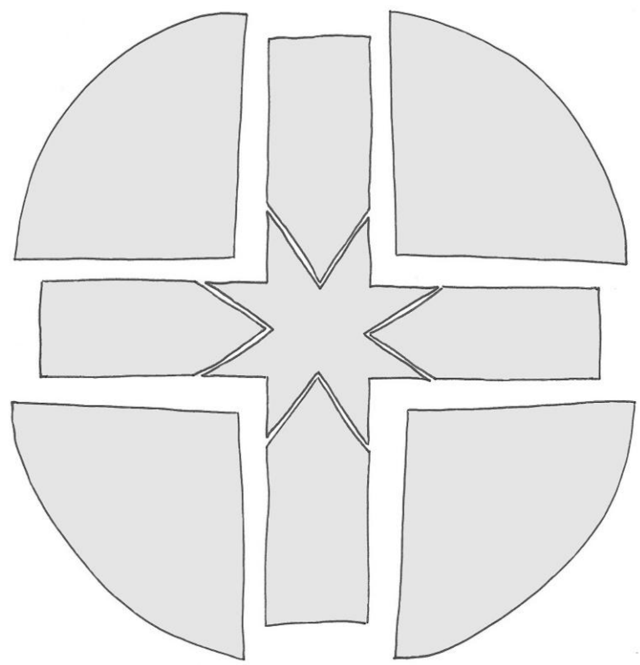


Figure 81: Right Order

- **Patents:** "Isn't this design/style patented?" It was, the original expanding table idea by Robert Jupe in 1835 and the modern self storing iteration by David Fletcher in 2002, #GB2396552. The 2002 patent was filed in Great Britain and expired 5 years later in 2007 due to "non-payment of renewal fee."