Arts & Crafts Style Lampshade

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Introduction

When I made a matched pair of table lamps my first impulse was to buy lampshades for them. However, after considerable searching I was unable to find affordable shades that would complement the lamps. Every combination gave the impression of two unrelated items put together. The only viable alternative was to make my own. What evolved turned out to be an interesting exercise in lap joinery and compound mitering.

This article describes the design and approach used to make the four-sided lampshades shown in Figure 1. The approach is easily extended to make lampshades with any number of sides. Tables and formulae are included to enable calculation of the lap joint and miter angles required, given the dimensions of the lampshade and the number of sides. A summary of the construction procedure is given at the end of this paper.

Figure 1 Four-sided Lampshade

Lampshade Design

The shape of the lampshade design is a truncated regular polyhedron. Because the sides are trapezoidal, the procedure for making one is the same for lampshades of all sizes and with any number of sides. The inside edges of the trapezoidal frames have rabbets to hold 1/8-inch Plexiglas panels. Fabric, glued to the outer surfaces of these panels provides a translucent pattern with colors and figures that can be chosen to fit the desired décor.

Although making the lampshade is mainly an exercise in lap joinery, choosing the overall width and height for a given application is subjective and requires careful planning and modeling. My approach was to make models using cardboard sides taped together. By fastening them to the harp of the lamp, I could judge the suitability of various choices of dimensions. The dimensions to estimate at this point are the width of the base (W_B), width of the top (W_T), and the vertical height (H). These dimensions are illustrated in Figure 2 for various numbers of sides. For my lamps, which stand 15½ inches from base to bottom of the harp, the dimensions I chose were W_B = 15", W_T = 4", and H = 7". When choosing your lampshade dimensions don't be overly influenced by the size of the harp. I sometimes find it necessary to bend the harp to hold the shade at the desired height but that is less important than compromising the aesthetic qualities of the lampshade. However, don't forget to make allowance for the light bulb.

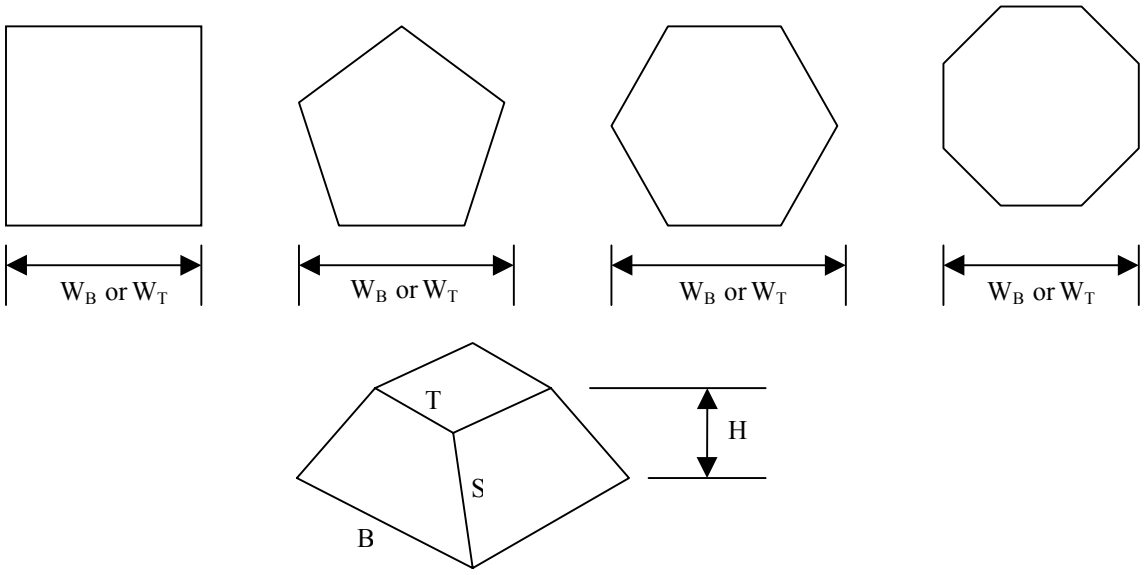

Figure 2 Measures of Lampshade Dimensions with Various Numbers of Sides

Calculating the dimensions and angles of the panels

Since my lampshades were four-sided, the base (B) and top (T) of the trapezoidal panels are equal to the overall widths of the base and top. If you decide to use a different number of sides these overall dimensions will need to be adjusted. Multiply W_B and W_T by the factors given in the "B and T" column of Table 1, below. Factors in the other columns are used in the equations for calculating the side length, S, and the blade tilt angle, μ for mitering the panel edges.

Table 1 Factors used to calculate panel parameters

Number of Sides	Factor for calculating B and T	Factor *k* for calculating side S	Factor *j* for calculating blade tilt angle μ
4	1.000	0.5000	2.0000
5	0.618	0.7236	1.4531
6	0.500	1.0000	1.1547
8	0.4142	1.7071	0.8284

Given the top and bottom dimensions of the panels, you can calculate the length of the sides (S), the angle to set the miter gauge for cutting the lap joints (λ), and the blade tilt angle (μ) to cut the compound miters along the sides using the following equations.

$$S = \sqrt{k(B-T)^2 + H^2}$$

$$\cos\lambda = \frac{B-T}{2S}$$

$$\mu = 90 - \arctan\left[\frac{2S}{j\sqrt{S^2 - k(B-T)^2}}\right]$$

Any error in cutting the miters will be multiplied by 2N, where N is the number of sides. Therefore, it is best to measure the dimensions of the completed frames and then compute the blade tilt angle using those values. For that reason the calculation of μ has been expressed in terms of S rather than H. In the construction process that follows it is important to remember that the computed lengths B, T, and S refer to the outside dimensions of the finished trapezoidal frames.

Construction

1. Making the frame pieces

The side, top, and bottom rails of each panel are made from pieces with a square cross-section. These should be cut to lengths several inches longer (mine were 4" longer) than their final sizes to make them easier to handle when cutting the lap joints. I began by selecting a piece of clear, straight grained cherry stock, and milling it to a thickness of ¾ inch. The rails were then ripped to ¾" width and then planed square to a final width and thickness of 5/8 inch. I then squared the ends and cut them to lengths about 4" greater than their finished values using a stop on the miter gauge extension. It doesn't matter what the oversize lengths are except that all components of the same type must have exactly the same length to facilitate cutting the lap joinery. Sufficient material should be cut to provide for spares, and scraps of reasonable length should be retained for use in setup. For consistency of color and grain I used a board that was large enough to provide all components.

2. Cutting the lap joinery

To facilitate cutting lap joints on the table saw, I attached a piece of ¾" MDF to the miter gauge, with sufficient length to extend beyond the dado blade when using either the right or left hand miter slot. In addition to minimizing tear-out, the MDF extension provides a convenient fence on which to clamp a hand screw for use as a stop. With the miter gauge set to 90°, I set the dado cutter width to the stock width, inserting shims, as needed, to get a good fit. Then I adjusted the depth of cut by trial and error using pieces of scrap.

Next, I set the miter gauge to the lap joint angle (λ) using a protractor to set a sliding bevel, and then using the bevel to set the miter gauge. An easy way to set the miter gauge is to insert two pennies in the slot to raise the bar. Placing the sliding bevel flat on the saw table, press the handle of the bevel against the bar and the arm against the miter gauge extension. The same method is used later to set the miter gauge to the opposite angle or to restore the same angle setting. Since it is difficult to set the computed angle exactly, any small error will be compensated for later when dados are cut in the top rail. For both accuracy of cut and ease of setting the location of the cut, the miter gauge should be used in the left hand slot when the angle is positive

(miter gauge turned clockwise), and in the right hand slot when the angle is negative (miter gauge turned counterclockwise).

With the miter gauge set to the value λ, I cut a dado about two inches from only one end of each bottom rail, top rail, and half of the side rails. A hand screw was clamped on the miter gauge extension to serve as a stop. Because the side rails on the left and right parts of the frames are antisymmetric, half of the side rails (four) will be cut with the miter gauge set to the value λ and the remaining side rails cut with the miter gauge set to -λ. The opposite ends of the bottom and top rails must be cut with the miter gauge set to -λ. Make sure that the surfaces being cut are the face grain sides, not the edge grain sides.

Since the dados at both ends of the side rails must be cut in the same direction, the next step is to dado the other ends of these rails before altering the miter gauge setting. On one side rail, mark a line across the piece using a square aligned with the dado edge closest to the end of the workpiece. Then measure off the distance S from that line toward the other end of the rail and mark a line across the piece. Extend this mark around to the adjacent side that will face the blade so it will be visible when lining up for the cut. To insure that the cuts will be made at the proper locations and directions, pencil I marked both edges of the dado slot to be cut. Turn the piece end-for-end and adjust the position of the side rail against the miter gauge extension so that the cut mark aligns with the outside edge of the dado blade. Clamp a hand screw or other stop onto the miter gauge extension at one end of the piece and make the cut. When satisfied that the cut is at the correct location cut dados in the remaining side rails. If you have made spare rails of each type, be sure to cut them too before removing the stops. Finally, change the miter gauge to the opposite angle and cut the dados in the other components using the same procedure.

To ensure that the frame pieces would fit together properly, I assembled two sides with a bottom rail and pressed one of the top rails into place before cutting its complementary dado. Minor adjustments required to make a clean fit were made by sliding the uncut side of the top rail in the side rail dado. When satisfied with the alignment, I marked the top rail where it contacted the inner edge of the side rail. This became the inner edge of the second top rail dado. Using the sliding bevel, I extended this mark to the side that would face the blade aligned it with the inner edge of the blade. Then I set a stop and cut the dados in the top rails. Finally, I dry assembled the remaining frames to ensure that all pieces were cut properly and fit together. If the surfaces of the mating rails are not flush, gently file the bottoms of their mating lap joints to remove irregularities and recheck the fit.

3. Cut rabbets to hold the Plexiglas

Rabbets must be cut on the inside edges of all frames to contain the Plexiglas panels. This is easiest to do on the router table using a rabbeting bit. I set the fence to yield a depth of ¼ inch, and set the height to make the cut 1/8-inch deep. (Note: Due to the small cross section of the rails, it is safer and better to use the fence for this operation than to depend on a bearing that may be mounted on the rabbeting bit). The cuts were made with the back surface of the rail against the fence and the inner surface down on the table. During this procedure I was careful to keep track of the edge to cut on each piece by making a chalk mark on edges where the cuts were to be made while they were assembled into a frame.

4. Glue-up the frames

The frames were glued up by placing a drop of PVA glue on one surface of each lap joint and clamping each corner with a spring clamp. Avoid using excess glue because squeeze-out is hard to clean up and the joint does not require much glue for strength. When the glue is dried trim the side rails that extend above the top and below the bottom rails flush with the top and bottom

rails. Avoid sanding on the outer edges of the sides since this could affect the quality of miters yet to be cut.

5. Cutting miters on the frame edges

With the frames completed, mitering the side rails is a safe operation because the rigid frame provides control of the piece as well as a reference surface for the miter. To guarantee that the side is parallel to the blade, Set the sliding bevel to the interior acute angle of the frame and adjust the miter gauge to that angle. It should be very close to the lap joint angle ($-\lambda$). The miter gauge should be in the left-hand slot of the table saw. Measure the frame dimensions to compute the blade tilt angle (μ) and set the blade to this angle using the sliding bevel.* Adjust the position of the frame to make the miter cut along one side and place a stop or clamp on the miter gauge extension to keep the frame from moving. Finally, make miter cuts on one side of each frame. Note that the overhang of the top rail is the same for all frames and provides a convenient point of support for the stop.

To miter the opposite side of a frame, reset the miter gauge to the opposite angle and place the frame on the table face up with the bottom rail against the miter gauge extension. Check the alignment of the side with the blade, set a stop, and cut the miters as before.

6. Glue-up of the lampshade assembly

When the frames are tilted to form a completed assembly, the inside bottom edges of the base rails become visible. To give the lampshade a trimmer look I routed a 45° chamfer on those edges before gluing up the frames. I also prepared the Plexiglas panels (see 8, below) and drilled for mounting screws prior to glue-up.

The mitered frames were prepared for glue-up by placing them, outside surface up, on a flat table with their mitered edges in contact. Strips of clear packing tape were then placed along the entire edge of each joint and on the edge of one free end. After taping the outside surfaces of the frames, I closed the assembly up to insure that the two end miters meet without force. If they do not close up, it may be necessary to recut or trim the miters slightly to make them close.

To prevent squeeze-out from contaminating the inner surfaces, I turned the assembly over and applied tape to the inside edge of the miters on each rail. After applying PVA glue to all mitered surfaces with a small brush, I folded the assembly together and wrapped the tape on the free end over the other end. When mating the free ends I set the assembly, bottom down, on the table so the ends would align properly. After the glue dried, I stripped off the packing tape, cleaned up any stray glue spots with a sharp chisel, and finish sanded the outside surfaces and corners.

7. Making top support members

To mount the lampshade on top of a harp, I made a simple cross-brace that was glued to opposite corners of the top rails. This brace was made of 5/8" wide by 3/8" thick cherry. The thinner material ensured that enough threads were exposed to screw on the finial. I joined the two pieces at the center with a lap joint and drilled a ¼" hole through the center to clear the threaded support on the harp. To fit the ends of the brace to the corners of the four-sided lampshade top I marked a line, centered lengthwise, on the underside of each brace arm and planed bevels to match the angle at the corners where the top rails meet. The completed cross-brace was then glued in place using a small weight to hold it down while the glue dried. If the number of sides is

* Note that the blade tilt angle is the angle you would set using the dial on the table saw; it is measured with respect a plane perpendicular to the saw table. I find it easiest to set the blade angle from the left side (for a right tilting arbor). If you use a protractor to set the sliding bevel to this angle, the value to use should be $180°-\mu$ because the protractor measures angles with respect to the plane of the saw table.

greater than four, it will be necessary to select other locations at which to glue the support members to the assembled frame.

The completed assembly was finished with a coat of shellac followed by two coats of Tried & True; a mixture of polymerized linseed oil and beeswax.

8. Preparing the Plexiglas panels

The Plexiglas panels are easy to cut on the table saw. To make efficient use of material, I used a rectangular sheet of 1/8" material of width equal to the height of the panels. With a layout of panels alternating between top and bottom edges, I used a length of (N-1)B + T, (where N is the number of sides) plus enough margin for the blade kerf. I set the miter gauge to the angle used to cut the miters and sawed off each panel. To assure an easy fit, I cut the panels about 1/16" less than the dimensions measured on the frames. Holes should be drilled in the corners to accommodate small wood screws (I used ¼" #2 round head screws) prior to glue-up of the assembly.

When the finishing was completed I applied fabric to the outside surfaces of the panels and then screwed them in place. For my lampshades, I used 100% cotton batik fabric. Being careful to orient the grain of the fabric such that it runs vertically with respect to the panels, I cut oversized pieces to the approximate shape of the panels. The fabric pieces were then glued to the panels using a spray adhesive and the overhangs were trimmed to the panel edges with a rotary fabric cutter. Each panel was slipped into the frame, fabric side out, and held in place by screws in the corners. In this way, the panels are removable so that fabrics can be changed. This is easy to do simply by lifting a corner and tearing off the material. The residue of spray glue does not need to be cleaned off. Simply spray on more adhesive and apply the new fabric.

Summary of Procedure

1. Determine lampshade parameters: vertical height (H); width of base (W_B); width of top (W_T). Use mock-ups to evaluate different options for the lamp.
2. Compute the parameters for trapezoidal frames: length of base (B); length of top (T); length of sides (S).
3. Prepare material with square cross-section for frames and cut pieces at least 4" longer than final length.
4. Set up dado blade to depth and width for lap joints and set miter gauge to calculated lap joint angle (λ).
5. Cut the lap joints as follows:
   - Mark outside faces with chalk.
   - Bottom and top rails: make one cut 2" from one end only; outside faces up.
   - Side rails are anti-symmetric. Make one cut 2" from one end only on half the rails. Measure and cut a second dado on the other ends. Outside faces down.
   - Change miter gauge to the complementary angle. Measure and cut dados in the bottom rails and on both ends of remaining side rails.
   - Assemble a set to form trapezoidal frame and mark best fitting location on top rails.
   - Cut final dados on top rails.

- Check fit of all components to make four trapezoidal frames. File inside surfaces of the lap joints as necessary to make them flush.

6. Chalk the inner edges of the frame pieces where rabbets are to be cut and then cut ¼" wide by 1/8" deep rabbets on the router table.
7. Glue-up frames.
8. Cut off extensions of side rails above top rails and below bottom rails. Leave others in place.
9. Set a sliding bevel to the inside angle between the base rail and one side rail, and set the miter gauge to this angle.
10. Measure the outside dimensions of the top, bottom and side rails of the completed frames. Compute the miter angle (μ), and set blade angle of table saw to this angle.
11. Cut the miters on both sides of the frames with the miter gauge set to the angle measured on the frame. Start with the top frame against the miter gauge extension and use a stop to maintain the same position for each frame. Change the miter gauge to the opposite frame interior angle and cut the other miters with the base against the miter gauge extension.
12. Chamfer the inside edges of the bottom rails (if desired) using a router table and fence.
13. Make the Plexiglas panels to fit frames, leaving a 1/16" margin to accommodate the fabric. Mark the panels for location and drill holes to accommodate #2 round head wood screws.
14. Glue up the frames to using clear packing tape to hold the mitered joints together.
15. Make and attach the top support brace.
16. Sand and finish the completed assembly.
17. Apply the fabric to panels with spray-on glue and attach the panels to inside of frames using screws in the corners of each panel.

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