

Building a Hexayurt with a Vestibule

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<http://philthysanchez.com/cib/2008/hexayurt>

These instructions are not intended to be a complete guide, but rather what I've learned from building my own, and should augment lots of other material you can find online. See, for example:

- <http://hexayurt.com/>
- http://www.appropedia.org/Hexayurt_Playa
- http://www.appropedia.org/Hexayurt_Playa_checklist

My instructions assume you want to make a Hexayurt with a vestibule (Figure 1). That means you will have a full sized door and won't have to crouch each time you go in and out of your home. How many times do you do that during a week at Burning man? In this regard I believe the vestibule is a big improvement over the classic Hexayurt design.



Figure 1: Hexayurt with vestibule

My instructions also assume you want beveled edges so the joints will nest tightly together. It is considerably more work cutting, and takes a bit more brainwork to keep straight, but beveled joints make assembly easier and will also provide more structural integrity than unbeveled edges. Also this uses 1 inch foam. Angles should be the same for 2 inch foam.

General guidelines:

1. Buy clean foam sheets, avoiding pieces that have punctures, bubbled surfaces, or ragged edges.
2. Work slowly and methodically to avoid making mistakes.
3. Handle the foam gently, especially the acute ends of cut triangles; they can break easily. Once the pieces are taped around the edges they are much more durable.
4. Sweep all work areas of debris. If the panels are placed on the ground or table, small pieces of hard debris will puncture the foil.
5. Do not attempt to rip the foil. It will continue to tear off the foam. Always use a knife or scissors. Do not attempt to tear tape off the foil. It will tear the foil away from the foam. Just leave stray bits of tape in place. So be careful about where you tape!
6. If you make small punctures in the foil, seal them immediately with clear packing tape to avoid a small tear in the foil from getting larger.
7. Marking: use a chalk line if you have one. Otherwise be careful to mark the diagonals accurately. Use a Sharpie pen or some other non-smudging permanent marker. Avoid marking on the unprinted side of the material (assuming you want the unmarked side on the exterior of your yurt).
8. Bevel edge cuts should be made on the printed side. See Figure 2, the printed side of the material is facing upward.
9. For door or window cuts:
 - a. Cuts should be made by hand.
 - b. On the hinge edge make cuts straight into the foam.

- c. On the other 3 edges make bevel cuts (~ 15°, does not need to be exact) so the door or window will close without scraping or hanging up.
10. If you are using a table saw:
- a. Make sure everyone wears a dust mask or respirator. Goggles will help if conditions become dusty.
 - b. Have at least 3 people for the cutting:
 - i. One person should keep a shop-vac focused near the blade to suck up foam dust.
 - ii. The other people can help feed the material through the saw.
 - c. This is basic table saw protocol: **make absolutely sure** the material stays flat on the table. If the material rises from the table while making bevel cuts you will remove excess material and your edges will not be straight. It may be helpful to use a paint roller to keep the material flat to the table
11. For cuts made by hand:
- a. Use a very sharp knife with a thin blade, such as for cutting a roast or filleting fish, or a utility knife if the blade is long enough to cut through the material at a 60° angle.
 - b. Do not use serrated knives.
 - c. Be very careful to keep body parts out of the way. It takes considerable force to cut the material, and if the knife slips you could cut yourself severely!

What to buy

1. 14 sheets of 1 inch Tuff-R
2. Many rolls of tape (either bi-directional filament tape or duct tape), the higher quality the better.
3. 2 sheets of thin plywood
4. 2 compression straps, at least 12 ft long (needs to wrap around all 14 sheets of foam plus the plywood and have enough extra webbing for tightening).
5. 1" aluminum angle flashing (8 ft)
6. 1 tarp, at least 18 ft x 15 ft

The Cutting Process

1. Mark all piece identifiers (**BOLD CAPS**) as shown with a Sharpie marker. This will reduce confusion as you work.
2. Cut the bevel edges for **5** wall pieces (**A**).
3. Cut the bevel edges for **1** vestibule front top (**B**). Do NOT cut door cuts.
 - a. 60° cuts will need to be made by hand as in Figure 2 unless you have a machine that will make very acute angular cuts.
 - b. Be very careful not to cut away excess material. You can always shave off more but it is impossible to add material where it was unintentionally removed!



Figure 2: freehand angular cut

4. Cut the bevel edges for **1** vestibule front bottom (**C**). Do NOT cut door cuts.
5. Cut the (**D/E**) sheet to 6' 11" in length.
 - a. Cut the sheet diagonally.

- b. Flip one triangle over and place the triangles together as shown in Figure 3, so you will know the proper orientation of the pieces

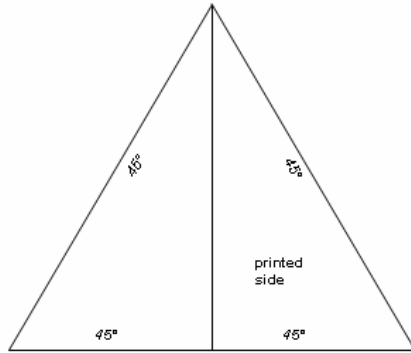


Figure 3: vestibule top

- c. Cut the bevels for the vestibule top as shown in Figure 3. One of these triangles is the only piece of the entire structure that will have printing on the outside.
6. Cut the **2** diagonals for **(F/J)** and **(G/K)**.
 - a. Cut the 45° bevels for **(F)** and **(G)**.
 - b. Cut the 60° bevels for **(F)** and **(G)**, by hand if necessary (see Figure 2).
 - c. Cut the 30° bevels for **(J)** and **(K)**.
7. Cut the **2** diagonals for **(H)** and **(I)** pieces, separating into their respective stacks.
 - a. Cut the bevel edges for **8 (H)** and **8 (I)** pieces.
8. Place the vestibule front panels **(B)** and **(C)** on the ground and spot tape together in a few places.
9. Make the door cuts. After the door sections are cut away from the rest of the panel, tape them back in place using hinged joints as described below.

Taping

1. Tape around all exposed edges of all sections to avoid MOOP¹.
2. To make hinges, whether for doors, windows, or for pieces that can be stored & transported together, use a taped hinge as shown in Figure 4. Making permanent hinges for some sections will reduce assembly time as well as minimize introducing dust in some of the taped sections (you do some of the taping off Playa).
 - a. The straight taped side should face outside (Figure 4, top).
 - b. After the straight tape is applied, fold backward and tape the exposed edges (Figure 4, center).
 - c. In its extended position, the hinge is shown in Figure 4, bottom.

¹ MOOP = Matter out of place

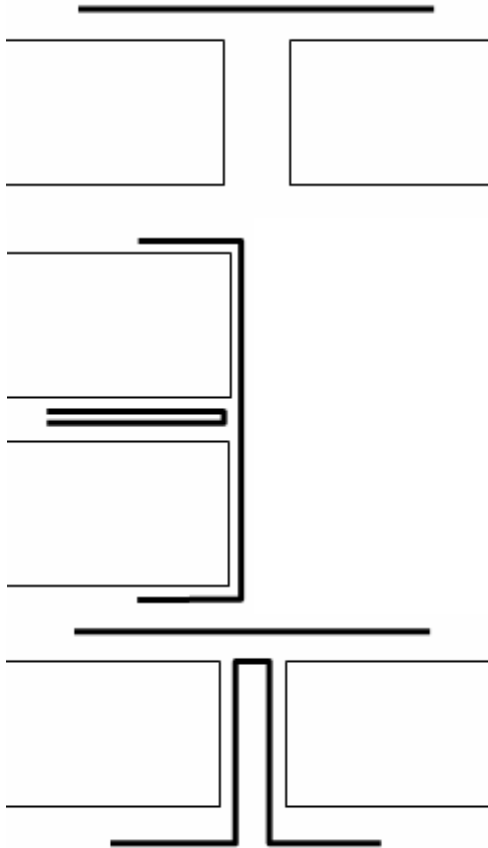


Figure 4: taping a hinge

3. Permanent hinges should be made for:
 - a. the 5 (**H/I**) roof panels (at the meeting of the long legs of the triangles)
 - b. the vestibule roof panels (**D/E**)
 - c. pairs of the wall panels
 - d. the vestibule top face (**B**) and one of its triangular walls (**F** or **G**)

Transporting/storage

1. Lay the 2 compression straps on the ground.
2. Place one plywood sheet on top of the straps (straps should be perpendicular to the longest axis of the plywood)
3. Place 1 of the wall panel hinged pairs on the plywood.
4. Stack all of the triangular pieces, nested to each other along the hypotenuse.
5. Place the final wall piece on top of the stack.
6. Place the 2nd plywood on the stack and tighten with the compression straps. You can now easily move the entire stack as one piece.
7. It is best to have 4 people for moving the stack, two people holding the bottom, and two people to keep the stack from falling.

Assembling

Have on hand a paint roller with an extended arm (or something functionally the same). Have lots of tape, scissors, knives, etc. Have at least 6 people willing to help for about 40 minutes. Have extra people if conditions are windy, just to hold panels down. Have several clean rags around to wipe surfaces free of dust before they get taped.

1. Assemble and tape the vestibule top section completely (**D/E/F/G**).
2. Tape the roof panels adjacent to the vestibule, joining to the vestibule.

3. Place the remaining roof panels loosely, spot taping together near the base of the roof. This will allow adjustment at the apex before final taping.
4. Have a person inside the roof to push roof panels at the apex until all pieces fit together neatly.
5. Tape the roof sections together.
 - a. This is not easy because now the apex is now 4 ft in the air and about 8 ft from the base. Unless you have abnormally long arms you won't be able to reach the apex manually.
 - b. The trick is to have one person hold one end of the tape. The 2nd person pulls the roll (keeping it quite taut) until they are separated by 18-20 ft, far enough to hold the tape over the roof. [Note: the joints between roof panels are ~9 ft in length ($\sqrt{4^2 + 8^2} = 8.94$).
 - c. They lower the tape down on the apex.
 - d. Keeping the tape taut, they continue to lower the tape along the roof joints.
 - e. A third person follows with the paint roller, tamping down the tape.
6. Place the floor tarp on the Playa at the location where the yurt will be stationed (you want to avoid moving the yurt once it is completely assembled).
7. Tape the walls together. They may not be perfectly hexagonal but the roof will be perfectly hexagonal, which will force walls to be hexagonal when the roof is placed on the walls.
8. Have 2 people inside the walls.
9. At least 4 people lift the roof and walk it over to the walls, passing to the people inside when necessary.
10. When the roof is placed on the walls, nudge all sections/joints in place.
11. Walk around the yurt, spot taping in a few places on each wall, just to anchor the roof to the walls. Once this is done, you can relieve all but one assistant.
12. Going around the entire wall-roof joint, have one person wipe away dust, while the 2nd person applies tape. Now the yurt is completely assembled. You may find it helpful to have the door open so that the hinge and jamb are lined up correctly before doing the final taping.
13. Tape the inside walls to the tarp to keep out dust.

Anchoring to the Playa

Rather than using the recommended method of using tape, PVC pipe sections, and rope to anchor the yurt, I devised a system that uses small pieces of 1" aluminum angle flashing to create a structurally solid way to anchor the panels directly to the ground without using guy lines that could trip people up. The yurt did not move at all in the 40+ mph winds we had in 2008 so I'll assume this method will work generally.

1. Purchase a long piece of aluminum angle flashing and cut it into about 4 inch sections.
2. Cut slits in the foam the length of the pieces of the flashing about 1 ft from the bottom edge. Insert the angle flashing as a sandwich through the slit. Sandwich two more pieces at the bottom edge of the wall (Figure 5, left).
3. Tape the flashing in place.

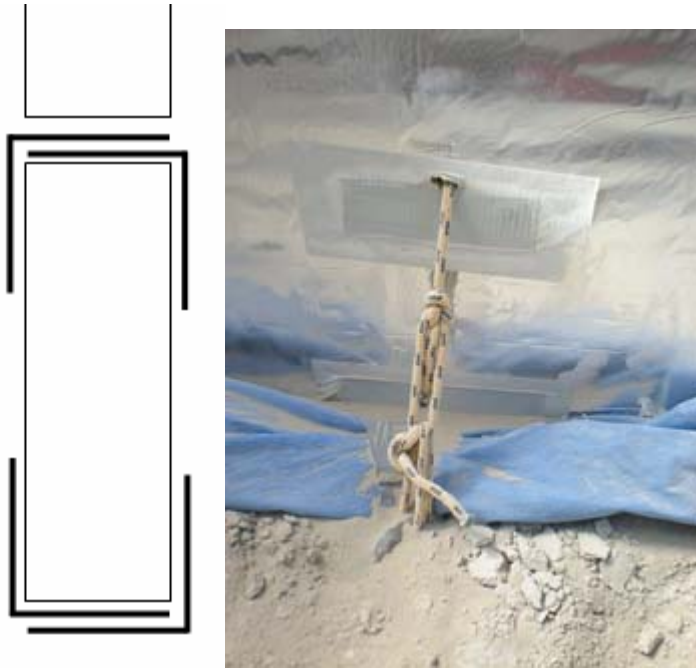


Figure 5: Anchoring system

4. Use a candy cane pushed into the Playa surface and tie a line loop.
5. Tighten with a trucker's hitch (Figure 5, right).
6. Now your yurt is completely assembled and anchored to the Playa!

Disassembly

1. Cut the tape at the wall-roof joint.
2. Remove the roof in reverse order as assembly,
3. Remove the candy canes and anchor lines.
4. Cut the tape between the walls and the tarp floor.
5. Cut the tape between the wall sections (but leave the permanently hinged sections together).
6. Cut the roof sections apart in reverse order of taping. You can access the entire roof section joints from inside the yurt.
7. Fold the pieces and sandwich between the plywood and fasten together with the straps.

Playa Assembly Instructions (reproduced from http://www.appropedia.org/Hexayurt_Playa_checklist)

Set Up

On the Playa.

1. General procedures
 1. Never peel tape back off the boards carelessly, because you can rip the foil right off the boards.
 2. Never cut the board material on the Playa because it generates moop.
 3. Careful juggling sharp knives and heavy rolls of tape!
 4. Now we have dust and heat to consider. Plan on working when dust and heat are minimized - early morning is the best time to do construction. If you arrive in the day, you can try the late afternoon, before dusk. Start early or you will be racing against darkness, which is no fun.
2. People. Plan on a core team of three to five people. You will need an additional half a dozen for about fifteen minutes when you lift the roof cone on to the walls.
3. **Start with a little magic.** Visualize clearly what you are about to build. This helps you do the construction efficiently. The clear picture in your mind helps you work correctly and coordinate with your helpers.

4. Draw a 8' radius hexagon on the ground. A little high school geometry helps!
 1. Put a tent peg in the ground at the center of the Hexayurt space.
 2. Take an 8' piece of string, and tie it to the tent peg.
 3. Tie the other end to another tent peg, and draw a circle in the Playa. This is the edge of your hexayurt.
 4. Now pull out the central tent peg. You have two tent pegs separated by 8' of string.
 5. Push one into the Playa at the edge of the circle. This is where one corner of your Hexayurt will go.
 6. Have somebody take the other peg and walk across the circle until the string is tight and they are also at the edge of the circle. Have them push the peg into the ground there. Together you are dividing the circle into six equal pieces - a hexagon, the basis of the Hexayurt.
 7. Repeat six times. You are basically using the string and tent pegs as a compass. At the end, you will come back to the beginning.
 8. Marking the ground this way is very satisfying. Ancient builders and geometers did exactly the same thing you are doing now.
 9. You may wish to complete this step using a marker pen on the tarp instead.
5. Unwrap the panels from the tarp. If you do this right, you should wind up with the panels sitting on the tarp, never having touched the Playa.

Assemble the Roof Cone

Do the roof cone.

1. You will need to learn this from the videos because it is hard to visualize from written instructions. This list is a reminder. Anybody want to take a crack at an illustrated guide?
 - o **VIDEO: [30 minute roof cone construction video](#)**
2. Take one wall panel and set it on its side. This panel is a prop to rest the roof cone on as it is assembled.
3. Take four roof triangles, two right and two left. Place them into two isosceles triangles. These triangles should be directly opposite each other, resting on the prop.
4. Make a tape anchor.
 - o **VIDEO: [making a tape anchor](#)**
 2. Cut 12" off a roll of tape and keep it.
 3. Take one of the 6" plastic pipes and the roll of tape. Roll the pipe in the tape two or three times.
 4. Now take the 12" piece of tape and stick six inches of it to the sticky side of the tape just above the pipe. This sticky-to-sticky connection is very strong.
 5. Then take the remaining length of the 12" piece of tape and wrap it around the pipe, so that the pipe cannot unroll from the tape.
 6. You need to see this done.
5. Position the tape anchor about six inches below the ground edge of an isosceles triangle, where the split in the two boards is. It is still attached to the roll of tape!
6. Have one person roll the tape about half way up the panels starting from the tape anchor.
7. A second person stands by the prop and reaches down to take the tape from the first person, and rolls the tape all the way to the top of the boards.
8. Make sure there is a gap between at the apex of the roof cone before going further. Pause, because this is important.
 - o **VIDEO: [mind the gap!](#)**
 - 1. At the point of the roof cone, where you are about to tape, there must be a gap. There is no gap between the two right-angle triangles making one roof triangle. That is not where we want the gap. We want the gap at the apex of the roof cone, between the point of the two triangles.

2. If this gap is not left, then as you get to the end of the roof cone process, it will become impossible to fit the pieces correctly. It is like trying to jam 105% into a pie chart - the pieces seem too big for the allotted gaps. If you wind up in this position, you will probably wind up trimming one of the boards and that is frustrating.
3. So how big should the gap be? About an inch and a half between the closest points. Possibly two inches. Too much is definitely better than too little.
4. The prop, however, won't hold the pieces in quite that alignment. Perhaps wad up a T-shirt and put it on top of the prop? I usually just fudge this, but I think making a tool by padding the prop is likely a better idea.
9. Now, gap assured, roll the tape down the other side. The person by the prop will roll it about half way, and a third person will take it down to the ground edge.
10. At that place, make another tape anchor. You must not cut the tape in the wrong place.
 0. To make this anchor, roll the tape out about 18" past the edge of the roof boards and do not let it touch anything. Cut the tape at this 18" point.
 1. Roll the piece of plastic pipe up the exposed piece of tape coming off the roof, and finish the tape anchor as you did the first one.
11. **Breathe. It's a lot when you see it written down. The first time you will wonder if you are doing it right. Many things which start that way turn out very well. You are now well started.**
12. Take two more boards. While the previous tape ran along the 8' vertical edge of two boards, the next straps of tape run up the hypotenuse. This is easy to see - you just take the next board, and fit it along side of what you have taped already, and you see you're taping slightly differently. Now the tape runs up the edge of the roof, and the boards meet at a slight angle.
13. But the procedure is exactly the same. Position the board, make an anchor, run it up half way, pass it off to the next person, ensure there's a bit of a gap (less important with each passing board), position the board on the other side, run the tape back down again (without cutting), make the anchor on the other end.
14. Keep going. In about 40 minutes, you will have done all the pieces but the last boards.
15. The last boards are different. Firstly, they can be really hard to get into position if you did not consciously leave a gap as you went about taping the apex.
16. Secondly, there is no place to stand to hand off the tape from one person to another.
17. Finally, the taping of the last board snaps the entire roof cone into its perfect geometrical shape. Right now, with an open edge, the roof cone can be too high or too low and you won't really notice. That is about to change.
18. Have one person get under the roof cone. Sit, don't crouch, you're going to be there for a while. Take the weight of the roof cone (it's light!) and pull out the prop. Your job is to move the roof cone up and down a little to help get all the pieces fitted in correctly.
19. Now position the last boards. The easiest way to do this is to splay the roof by having the person inside lower it a little, then slide the last two boards into position.
 - o **VIDEO: [adjusting a roof cone board.](#)**
20. Then, if they fit nicely, have the person inside lift the roof cone gently until the ground edges of the boards come tightly together, forming a perfect roof cone.
21. If it worked that way, thank your gods. Now quickly make another tape anchor on a roll, and stretch out 20 feet of tape between you and another person. Keep it pulled very tight indeed. Walk so you are on opposite points of the roof cone.
 - o **VIDEO: [taping the final roof cone seam.](#)**
22. Now gently, gently lower the tape until the tape touches the very point of the roof cone. Keep it tight. If it is positioned correctly, then lower your end of the tape towards the ground edge, patting it down against the seam with a stick or a broom. Make the final tape anchor, and laugh at your friend who is stuck under the roof cone.

0. It's never quite this easy. Usually those last boards need some force to position them correctly. There's shoving and swearing and cajoling. Sometimes you have to trim a board.
 1. How far out of whack can it be and still work? How precise do you have to be? Well, that tape is six inches wide. Any gap should be bridgeable by the tape, and still have good adhesion on both sides, so you have about two inches to play with. However, I've seen much wider gaps handled. You can actually kind of screw this up and still have a perfectly sturdy Hexayurt.
 2. When in doubt, remember this golden rule: it's better to trim the boards at the point, so they all fit, than to trim them at the base, which distorts the shape of the roof cone where it joins the walls.
23. (Optionally) lift the edge of the roof cone to let your friend out.

Assemble the Walls

Do the walls. This is the easy bit.

1. In terms of positioning, you can either move the roof cone away and work on the tarp, or you can "open" the walls slightly so they fit around the roof cone. Either way works. Watch, if you move things off the tarp, that they do not get dusty. If they do get dusty, wipe them down with a damp cloth and dry them before attempting to tape them to things.
2. Have two people take one panel each and hold them in position while a third person handles the tape.
3. Put the walls roughly in position over the hexagon you drew. This helps tape the angle correctly. Also the angle that the boards make to each other stops the walls you have taped already falling over.
4. Tape all six of the walls into shape, but leave one connection open. It can be very useful to be able to get in and out of the walls quickly.

[Put the Roof Cone on the Walls

This bit is pretty easy too!

- **VIDEO:** [joining the roof to the walls.](#)
1. First, find some helpers. 9 is a good number.
 2. You want six people to lift the roof cone. Each should stand in the middle of a wall with their hands spread as wide as possible, and they should lift in a coordinated fashion.
 3. If the walls are positioned just outside of the roof cone, around it, the lifters should now step under the roof cone and lower it close to wall height.
 4. If the walls are beside the roof cone, the lifters should carry the roof cone over the walls.
 5. Either way, the hustlers should now position the walls under the roof cone.
 6. Before you start to tape, get things lined up. Make sure that all the corners, all the way around, are about right.
 7. Now tape. Start in the middle of a wall, and put the end of the tape over the seam between roof and wall. This part is pure magic! You run the tape all the way around the building, a single unbroken strand that acts just like the tension ring in a yurt. It's also fun because the tape makes a nice noise as you zoom it out along each side, and people get very excited.
 8. When you get to a tape anchor, you have a choice. Over or under? I've tried it both ways and I can't figure out which is best, so I'm going to suggest you go over the tape which holds the tape anchors, so that the actual plastic tubes stick out just under the tension ring. Going under the tape anchors is fine too, however.
 9. Now cut the tape that is currently holding the door closed and let your friends in/out.

Tie it to the Playa

Almost done! Almost Done!

1. The Hexayurt sits on the tarp, and is not yet guyed down.
2. Go inside of the Hexayurt and tape the joint between the wall and the floor. If you are feeling fussy, do this inside and out. This is your dust lock and really makes life much more pleasant.

3. Now cut away the excess tarp, or just leave it. This may depend on your siting.
4. Now drive in your tent pegs. They should be pretty close to the bottom of the yurt. Make sure to pad the ends and mark the guy lines with something easy to see at night.
5. Run the rope through the plastic tubes at in each tape anchor.
6. Guy that puppy down. I, personally, favor the "trucker's hitch" to get a good, tight guy line.
7. Basically, tie the rope through the plastic pipe, and run the free end down through the tent peg and back up. Put it through the triangle made where the rope is tied through the pipe, and pull until it is tight enough for your liking. Then tie it off just below the triangle.

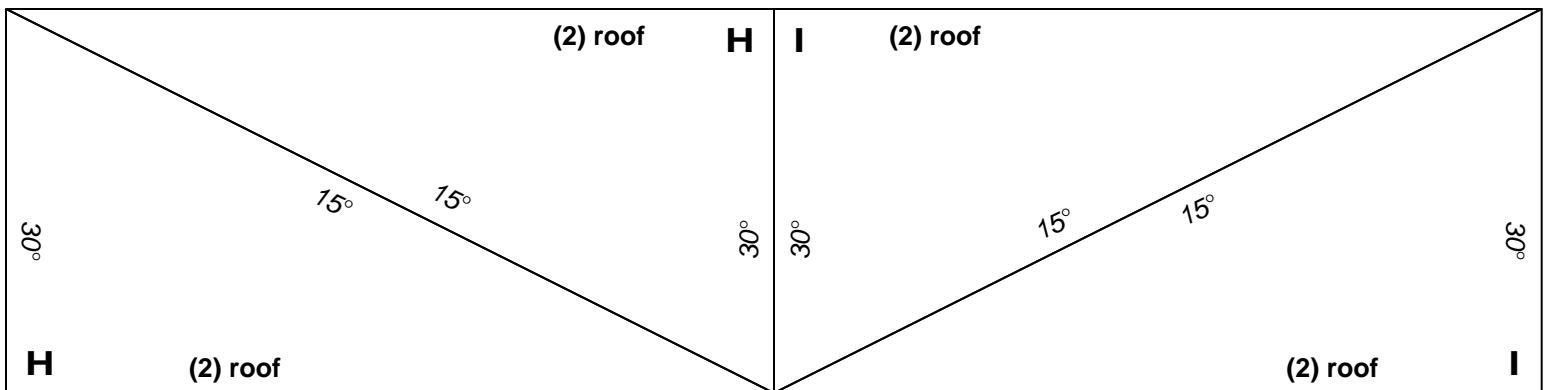
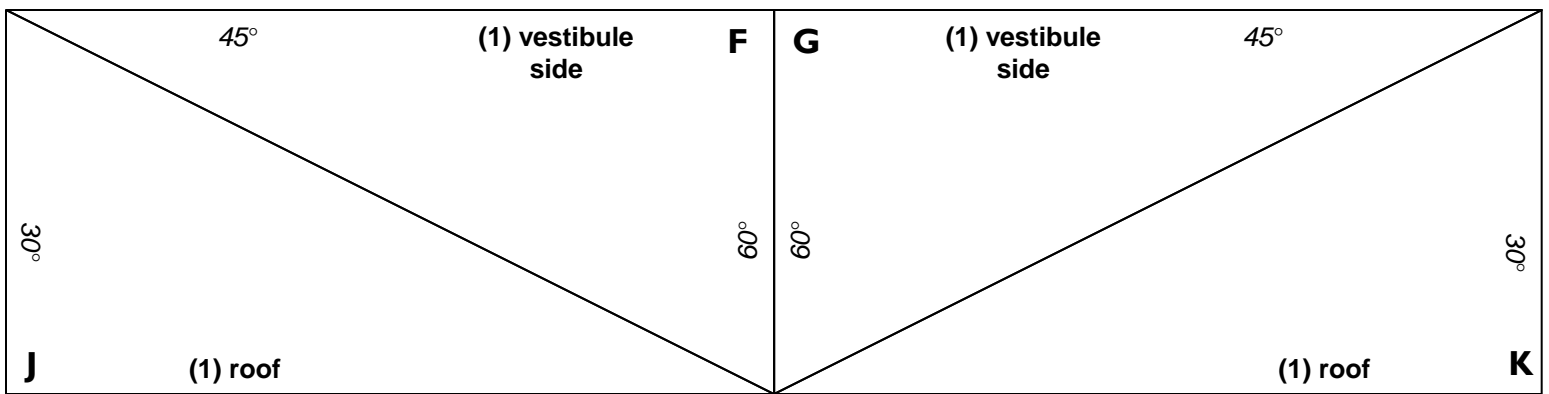
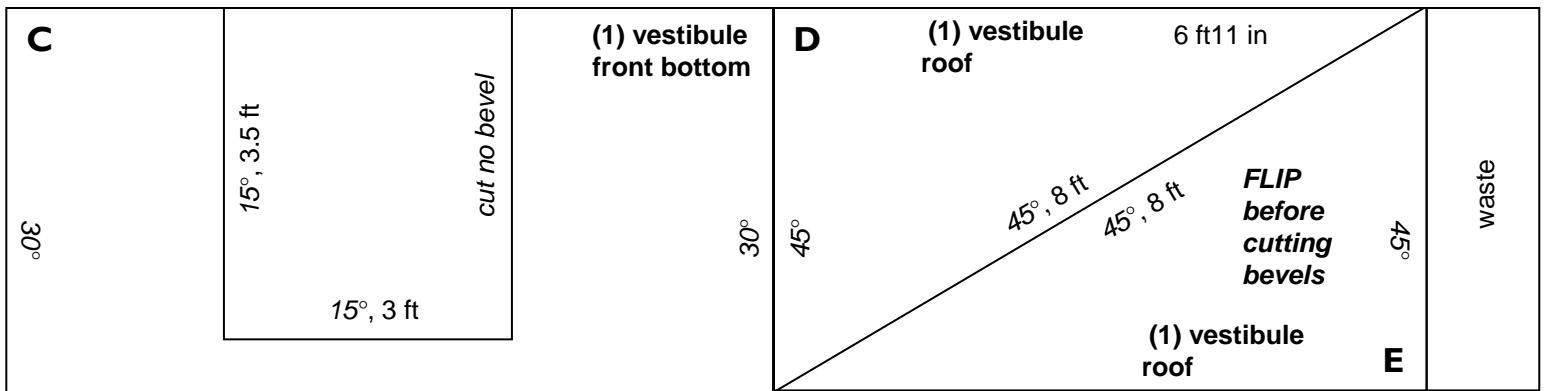
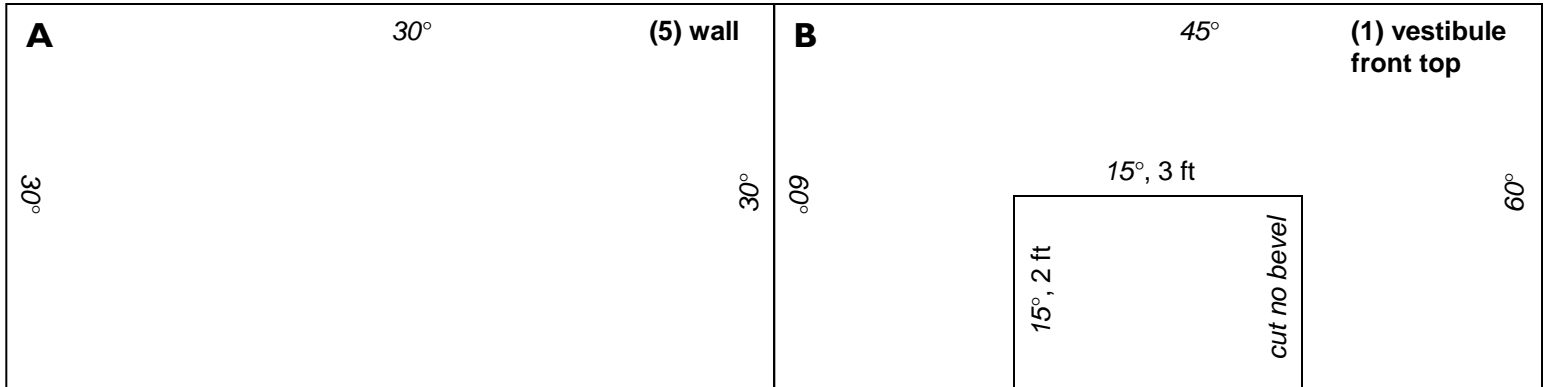
Final Finish Work

1. Tape your furnace filters to the outside of the hexayurt, over your vents, so that if you bang the dust off them it falls on the outside of the building, not the inside.
2. Put the foil tape over your exposed filament tape seams to protect them from fire. This is really important. In 2009 we'll have a tape which combines the filament tape and the foil tape in a single product, but it is not here yet.
3. **You are done.**

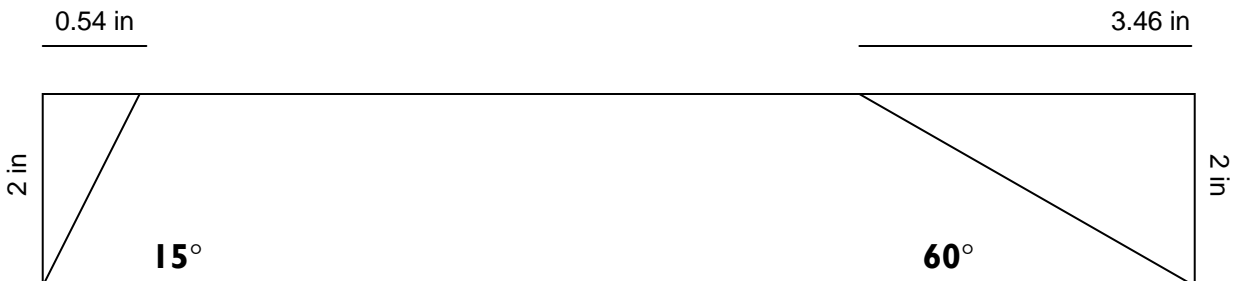
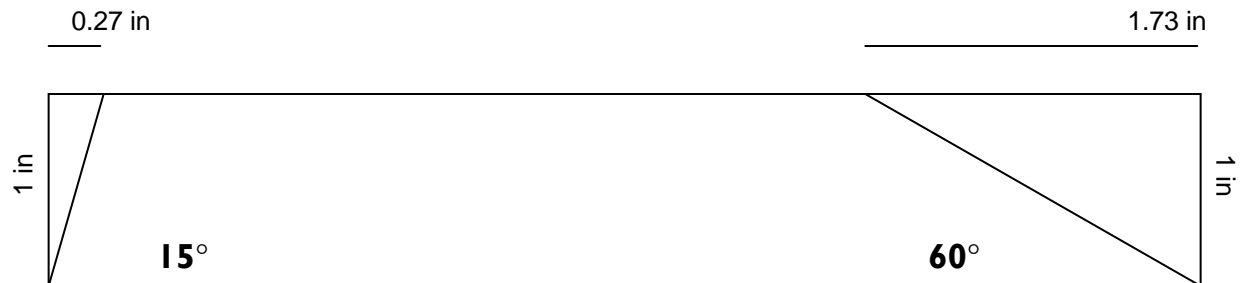
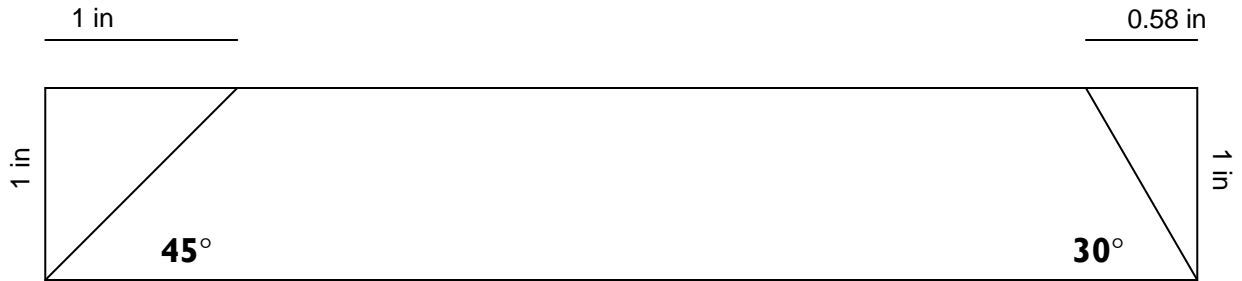
Congratulations!

Measuring dimensions and cuts

Sheets of TuffR measure 4 x 8 ft. Cuts and bevels are indicated with *italics*. Dimensions are indicated where appropriate. Edges that have no indication of bevel are not cut. See following page for measurement of bevels for cutting. (Parentheses) indicate the number of sheets/pieces. Pieces are identified with **BOLD CAPS**.



Measuring edge cut angles



```
f <- function(degrees=45, y=1) {  
  rad <- (90-degrees) / 360 * 2 * pi  
  x <- y/tan(rad)  
  x <- round(x,2)  
  return(x)  
}
```

```
> f(c(15,30,45,60),1)  
[1] 0.27 0.58 1.00 1.73  
> f(c(15,30,45,60),2)  
[1] 0.54 1.15 2.00 3.46
```