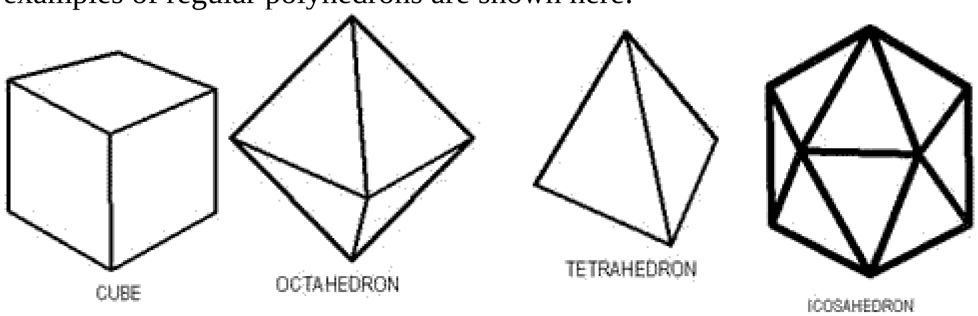
16’ 8” Bolt-Together Dome

R. Buckminster Fuller was a visionary born near the end of the nineteenth century. As a man concerned about the world’s shortages, he invented the geodesic dome as a means of enclosing large volumes with a minimum of material.

I first built this dome frame in the early seventies. Since then this structure has served as:

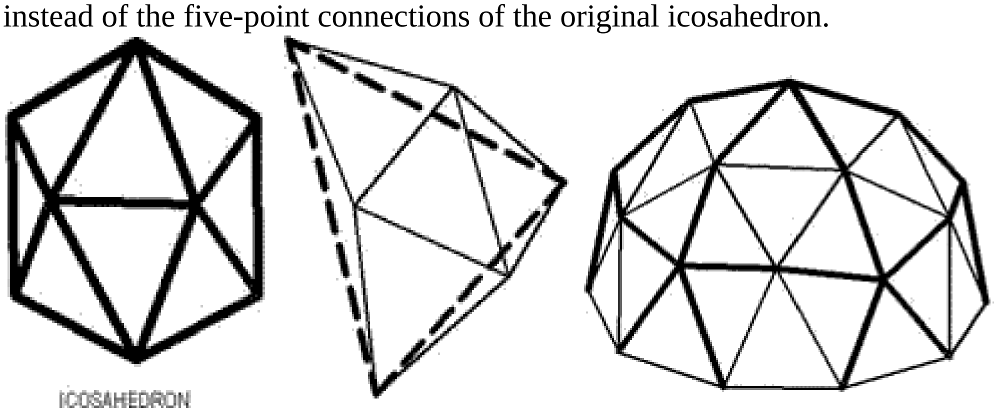
- Shade
- Hammock support
- Tent in various campgrounds
- Child’s swing support
- Bedroom
- Greenhouse
- Storage
- Shop
- Swap-meet shelter
- Garage
- Cement form
- Instant cash when a passing stranger wanted it bad enough.

A solid object with all its surfaces the same shape and size is called a “regular polyhedron.” A few examples of regular polyhedrons are shown here:

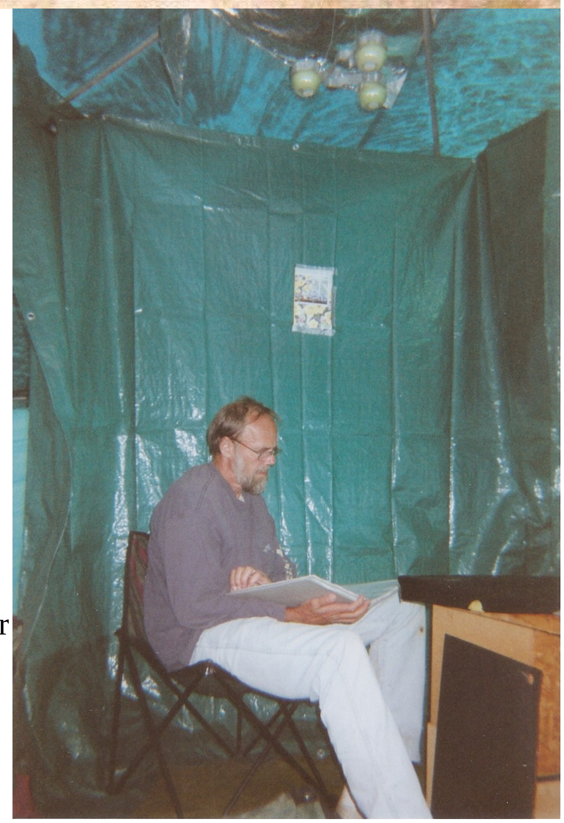


A geodesic dome is usually created by adding additional faces to a polyhedron. Since the icosahedron comes the closest to being a sphere, it is the one most often used for this purpose.

Picture a sphere just big enough to surround a polyhedron. Now stretch the center-point of each line so it touches the sphere, and connect these points with additional straight lines. It is important to note that length of these additional lines will be longer than the others (The darker lines in the dome illustration below represent the shorter lengths). Also, notice that their broken ends connect six lines, instead of the five-point connections of the original icosahedron.



We have just created the simplest form of geodesic dome. If we wanted to get more complicated, we could now take the centers of each of these new lines and project them to the sphere, and so on. For our dome, however, we’ll keep it simple.



The frame for this 16'8” diameter dome can be built for about $270 (as of 2020). Properly covered it can be weather-proof and easy to heat. The cost of membrane coverings varies widely, but is typically less than half the cost of the frame. The frame dismantles down to a bundle of struts a little over 5 feet long with a weight of less than 150 lbs.

The photo on the left was occupied by otherwise homeless people for a number of years. The next photo shows the frame providing my wife and I a shelter on a primitive camp site that we had rented for a week. As seen, the covering could be opened for fresh air in the day time. It took us less than an hour and a half to set up camp.

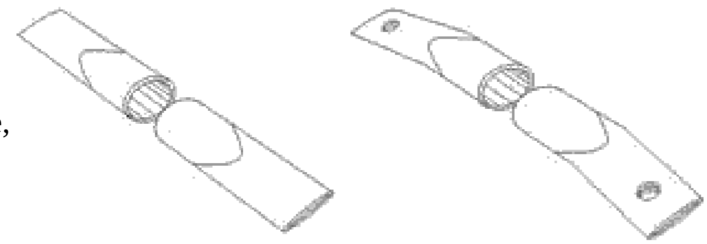
The interior view on the right shows the partition that walls off the master bedroom and bathroom from the kitchen-dining-living room. You can also see the chandelier comprised of scroll-work from a screen door decoration – with a capacity of up to eight votive candles. (Yes, there’s even artwork on the walls – eat your heart out Hearst Castle).

The entire camp loaded nicely into the 6'-long bed of a compact pickup, and I could still see over the load through the rear-view mirror. When we would rent a campsite for a week at a time the appointments of this cabin included a self-contained flush toilet and a bath pan we would use for hot solar-heated baths every afternoon. Other embellishments included the kitchen, wood stove space heating, lighting, chairs and hammocks as desired. From this campsite base we would tour an area with all the convenience of a nearby home (using the economy vehicle that carried it).

This dome requires two different strut lengths so I calculated where to cut a 10' piece of conduit so I would get a long one and a short one out of each stick (that is how it came out to 16' 8-1/2” diameter). You need five more long ones than short ones, so for the 65 struts required, you'll need to buy 35 10' sticks. Cut each one 63-9/16” from one end, and flatten about 2” on each end of the two resulting pieces. I have found that about a 3-pound hammer works best (for me) and a stump or “biscuit” of wood makes a good anvil for this application.

Make sure that the flattened ends are in line with each other, rather than twisted into different planes. Twenty-six 1/4” X 1-1/2” bolts plus nuts are needed to bolt this frame together. The nuts are applied to the inside, and I usually put pieces of tape over the heads so it they won't wear holes in the coverings

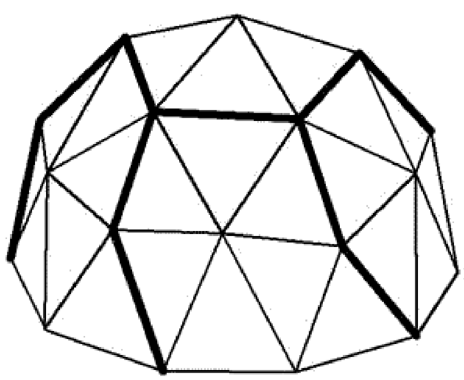
Do not use a driveway, concrete floor, or concrete anything else as an anvil. The repeated shock of even this small hammer will begin to produce cracks far sooner than you might imagine. If you do happen to have a steel anvil available, make sure it's in the middle of a wooden table, or otherwise isolated from any concrete slab. Bend the ends about 15 degrees in the same direction, so they will be tangent to the same 16' sphere.



Use a center-punch to mark a drill position in the center of each flattened area, about ½ inch in from each end. I have found that if you use a wooden backing, and drive the punch hard (almost through the metal) it takes a whole lot less time to drill the holes.

Drill a ¼" or 5/32" hole in each end of each piece, and remove the burrs so fingers won't be sliced during assembly. (A ¼" drill works, but 5/32" makes assembly easier.) Also, I would recommend using a drill press for this operation, because I once saw an electric hand drill burn up during this very process. Of course if you are patient like I'm not, you could periodically give the drill time to cool down.

Coverings for this dome have included various forms of plastic, a parachute, wood, and even cement. One I've found surprisingly satisfactory is 6-mil black plastic lightly sprayed on both sides with aluminum paint. The aluminizing radically reduces the heating of the sun on summer days, and helps trap the radiant heat of a camp stove and bodies by night. The covering I am recommending most these days is the Durable Covering made from landscape fabric and a solar roof coating described on my web site (**01020 Durable covering**)



There are polymer roof coatings you can paint on that some claim will last for ten years. I can personally vouch for at least that span. Apply this to tarps or plastic.

I have a 20' diameter structure covered with 4 mil black plastic sprayed with aluminum paint on the inside and coated with a UV-resistant polymer on the outside. The plastic isn't all that strong, so I've begun to apply sections of woven tarp glued to it by the polymer, and then painted over. I'm expecting this to hold up for quite a while. Even if nicks and tears did occur in normal usage, this type of repair could maintain it indefinitely. If you want it to last forever, embed some window screen in the coating.

I will have to admit that after a few years I have noticed at least a little flaking of the aluminum paint off the ceiling – presumably due to moisture condensing near the top.

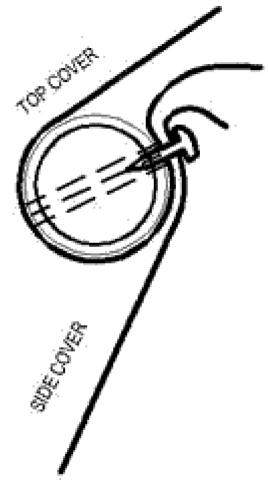
The method of covering I find most versatile is to divide a covering of plastic or tarp into six pieces – one for the top, and five around the sides. The boundaries of these pieces are outlined by the heavier lines on the sketch.

The covering pieces are attached by pulling their edges around the struts indicated by the heavy lines above, and hooking them on #10 x ¾" sheet metal screws spaced 8" apart. Seven screws per strut, with the middle one centered, work out nicely for these lengths. The screws should be installed in the same plane as the flattened ends.

Five long struts with screws will be needed to secure the top cover, and ten short struts with screws will be needed to run down the sides.

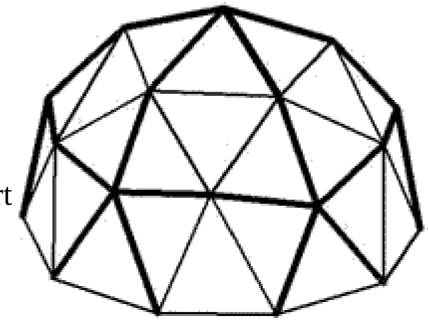
The edges of temporary coverings of plastic sheeting may be impaled on the heads of the screws. More substantial materials can be fitted with grommets.

When forming a two-dimensional sheet to a three dimensional surface, you'll need to take up some slack around the edges. Fold the excess along one of the struts and secure on both sides with duct tape (unless you feel like sewing).
By overlapping the edges of the coverings as shown here, you can get a pretty good degree of protection from the elements.



Assembly

In taking another look at the next illustration, notice that five short struts (indicated by the heavier lines) will join at the original points of the icosahedron. The other ends of these struts are joined by four long struts and one other short strut.



There may be a hundred different sequences for bolting this thing together, but here are a couple of suggestions to get you started:

Besides the struts (preferably some with sheet metal screws), nuts and bolts, it's nice to have a few tools. Although a pair of 7/16" end wrenches can do this, a ratchet fitted with a deep 7/16" socket is a great help. If you bought carriage bolts (as I prefer) instead of hex-head, you'll need a pair of heavy vice-grips to grasp the heads. Vice-grips are handy anyway to help adjust errant strut ends and to compress stacks of them while bolting. You should also have a hammer, something to stand on, and a friend.

1. Lay out a circle of ten long struts on the ground. This will establish the size and location of the finished structure, and leave you with only fifty-five more struts to worry about.
2. Build the dome up to the zigzagging ring of ten short struts (heavy lines) about four feet off the ground. Don't tighten the nuts down just yet; leave flexibility during the assembly process.
3. Connect additional struts to join a ring of five long struts near the top.
4. Join the remaining top five struts with a single bolt into a spoke pattern, and handle this as a group. And do tighten down this central nut and bolt for easier handling as a single unit while connecting it to the ring of five long struts now around the top.
5. Once everything is together, walk around the frame a couple of times adjusting the position of each of the ten connections on the ground to relieve stresses and adapt to any irregularities.
6. Tighten everything down, and go around lightly tapping in all the sharp edges on the ends of the struts with your hammer, so you won't tear your covering. I also like to add a piece of duct tape over each of the bolt heads to further reduce wear on the covering. At this point you can freely climb on it if you keep your hands and feet close to the hubs.

As you build it, the sheet-metal screws in the five long struts around the top should be aimed inwards, and the screws on the short struts all pointing the same direction. This will give you consistency and a water-shedding overlap when the covering is applied.

This structure has quite a bit of volume for its weight, so under windy conditions it is better to tie it down than to watch it roll across your yard (as my wife once did while I was out of town).

One secure way of tying it down is to flatten and drill one end of short (about one foot) pieces of tubing. Dig small holes under the connections on the ground, bolt on the short pieces so they are hanging in the holes, and cast them in concrete. Another way is to dig a ditch about 6" deep around the perimeter and lay the bottom of the plastic in it. When this "skirt" is covered with dirt, it makes a secure, draft-free seal.