AUTODESK Instructables

Magnetic Acrylic Rubik's Cube

By gfixler in LivingToys & Games

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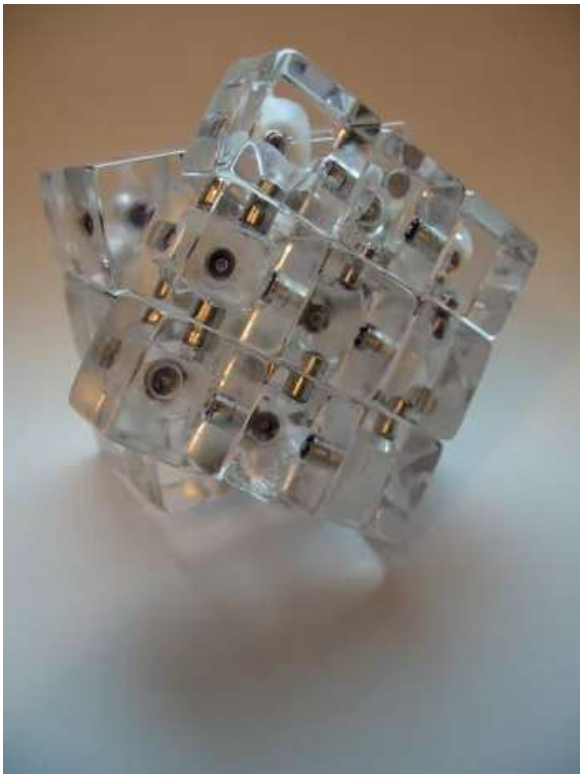
Introduction: Magnetic Acrylic Rubik's Cube



27 3/4" clear acrylic cubes are drilled with 108 3/16" holes, fitted with 108 D32 neodymium disc magnets with proper polarities facing out from each, and assembled into a size-matched magnetic version of the original Rubik's Cube.

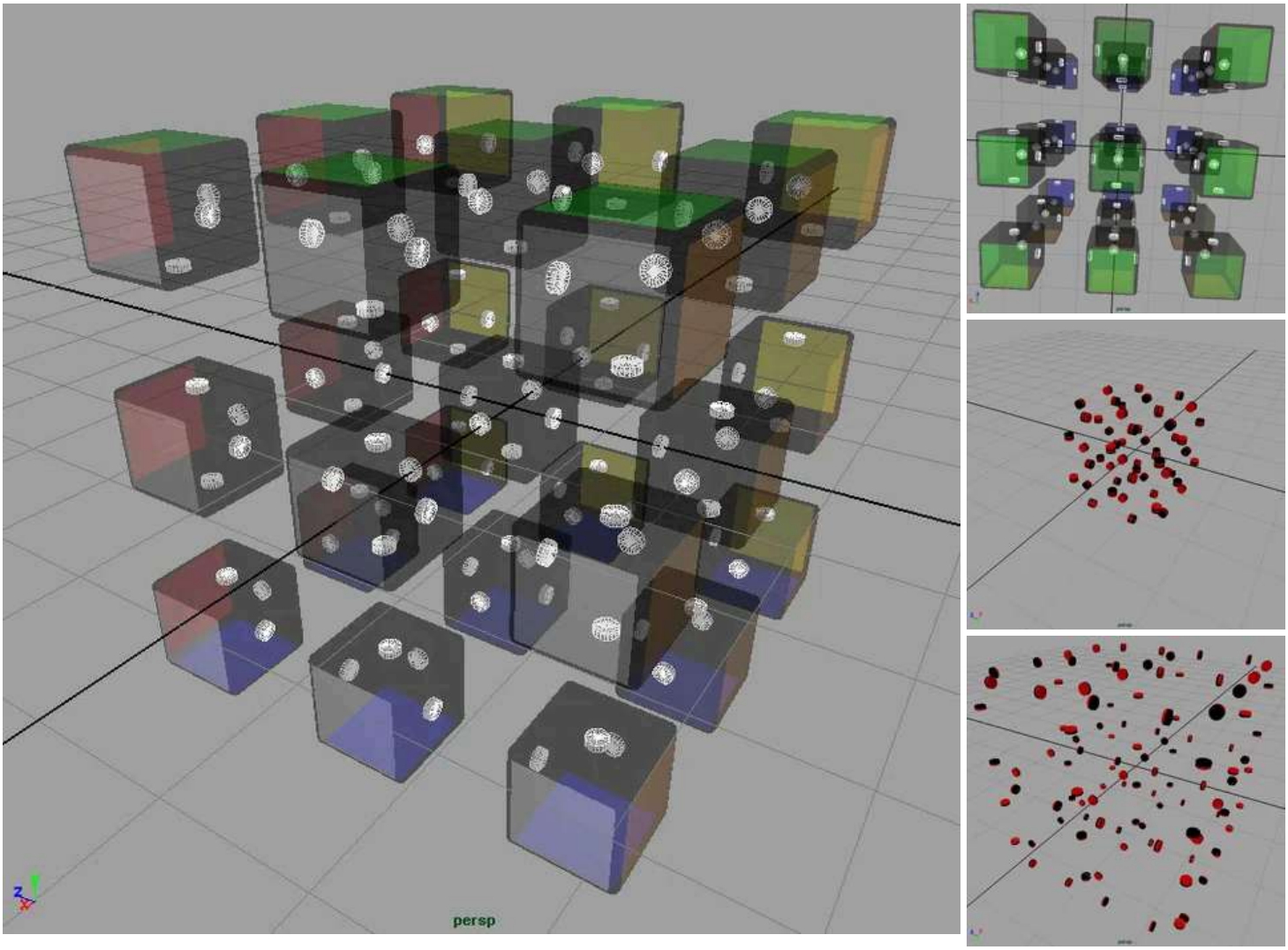
Update: Instructables user burzvingion has made a beautiful red translucent dice version of this cube. Make sure you check it out!

Tons more pictures of the process can be seen in

The pre-build gallery:
http://flickr.com/photos/garyfixler/sets/72057594101653870/

The build gallery:
http://flickr.com/photos/garyfixler/sets/72057594105668430/

Step 1: Plan Out Polarities



Before I devoted my time to this idea, which came to me while imagining a version of the cube that didn't need the intricate connecting tabs found inside a cube, I checked Google for magnetic rubik's cubes, finding none (though a friend found one (theoretically) available in China by removing the 's from rubik the day before I finished this thing). Then I mocked up a 3D version in Maya to figure out the polarities of the magnets to see if it would remain sound as faces were spun all around. It appeared that it would.

Step 2: Get Some Cubes

I researched cubes of all sorts online, including wooden blocks, "learning cubes," cubes of ABS, PVC, etc, and finally settled on 3/4" clear cast acrylic cubes from Tap Plastics:

http://www.tapplastics.com/shop/product.php?pid=136&

I got 3 sets of 10, as I needed 27. The extra 3 helped me test things out, which saved me some big trouble. These aren't all that precise, with romboid and trapezoidal angles aplenty, but in the end, they work well, especially as they're nicely rounded.

Step 3: Get Some Magnets

I found K&J magnetics through Google:

http://www.kjmagnetics.com/

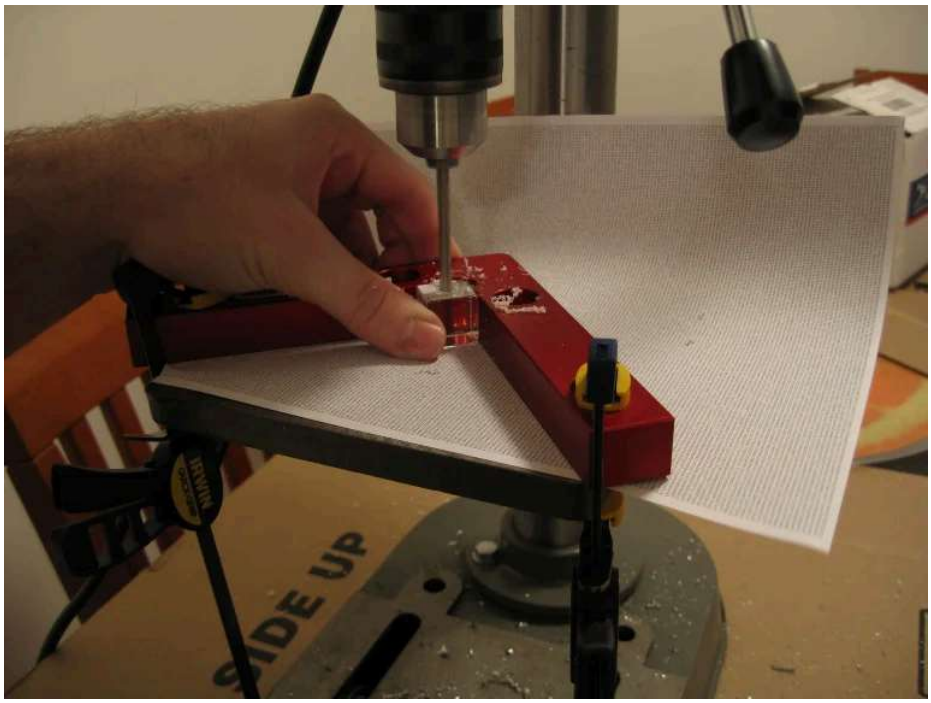
They have a huge selection, and I settled on their D32 3/16" disc magnets, which are 3/16" tall.

http://www.kjmagnetics.com/proddetail.asp?prod=D32

I got a pack of 100, and a pack of 25. I needed 108 for the cube prototype. If I build another, I'm going to beef up 12 of the magnets - the 6 pairs that form the axles off the center cube, probably to twice the width, perhaps to the D63:

http://www.kjmagnetics.com/proddetail.asp?prod=D63

Step 4: Set Up the Drill Press



I don't have a shop at the moment, so I had to settle on a cheap drill press on the dining room table. I used a needlessly high-precision CNC-milled clamping square from Woodpeckers, makers of fine, high-tolerance machining guides:

http://www.woodpeck.com/groupclampingsquare.html

They have a feast of uber precision stuff:
http://www.woodpeck.com/

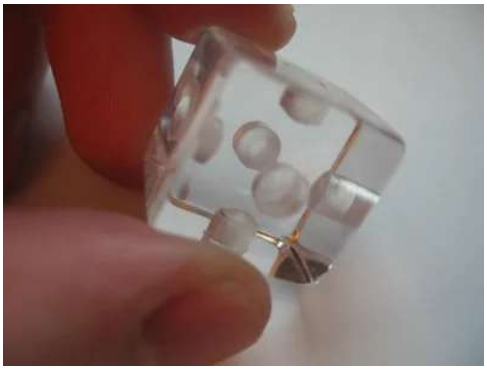
I held the clamp guides in place with some small Irwin Quick-Clamps, and later, for some more stability, with standard metal C clamps.

To align things, I eyeballed it: I'd get it about right, clamp it down, then press the non-spinning bit into the acrylic to make a tiny dent, then turned the cube 90 degrees and pressed again. When I got this to make a perfect tiny X in the acrylic, I knew it was pretty good. The cubes aren't accurate enough to be bothered with anything more precise than that.

Step 5: Get Your Polarities Straight

It's crucial that all these axially-polarized disc magnets are put in the right way, and I'm glad to say I didn't mess this up once in all 108 magnets. To keep me straight as to which side of each magnet was which, I stuck them all together in one long rod, then drew a Sharpie dot on one end, and peeled that magnet off, and repeated, all the way down. Now they all had a visible polarity, though I don't know still which was N or S.

Step 6: Drill Out the Central Piece



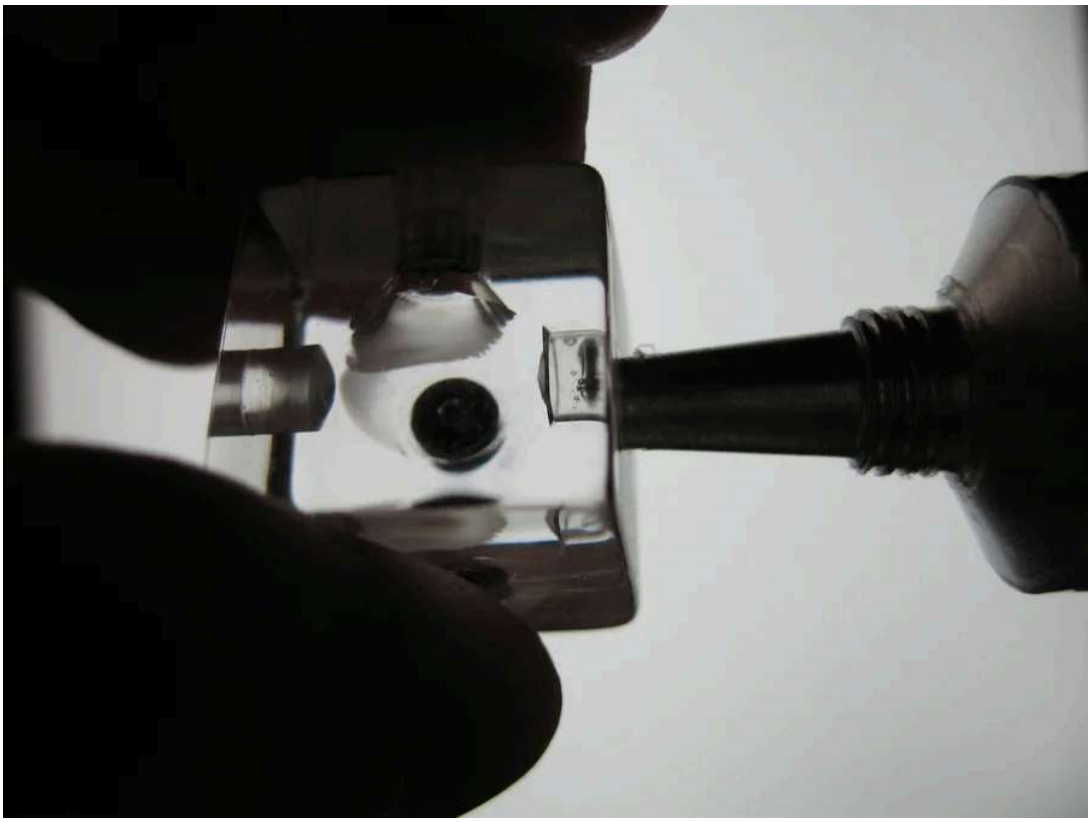
The central piece requires 6 holes, one per side, dead center. At first, I tried using a drill stop clamped onto the bit itself, but this is disasterous. The acrylic going up the flutes gets caught in there, and becomes a heated spinneret of fibers that instantly wraps around the bit, creating a solid acrylic chamfer between the bit and stop that then immediately cuts conically into the plastic. Once I remembered that my drill press had a stop built in, I got perfectly clean holes every time.

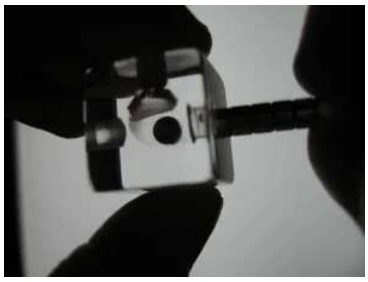
I drilled all holes for the project a little shallow first, then tested with a magnet as I slightly drilled more each time, up to the stop value I set in, until the magnet was just a hair's width lower than the surface of the cubes. As the cubes aren't all exact, I couldn't just rely on the stop itself.

The trick is to not let the magnets touch. In that last hair's width, their force becomes tremendous, and it's much harder to shear them apart. Better to let them be lower than the surface, and have only the acrylic surfaces slide against each other.

The magnets themselves slid in to an almost air-tight seal. Their slippery nickel-plating helped a lot here. To get the magnet back out after I tested it, I simply pushed the block up against part of the drill press, and it fly out and stick to the metal. In this way, I could keep drilling just a bit more and dropping the magnet back in to test for the right depth. Many times, however, the holes were the perfect depth after the first drilling.

Step 7: Glue in the Magnets





Without prior testing, I settled on Duco Cement from my local hardware store. You can see in the first two images that I'd put a bit of the glue in the hole, then push the rod of magnets into it, and slide the rod sideways to leave the tip magnet in the hole - always remembering to check the polarity.

In the third image, you'll see an interesting phenomenon of my materials choices. Duco Cement eats through faults in acrylic. As such, the circle at the end of the bored shaft, where it meets the crown, would "bloom" outward at a roughly 45 degree angle cone. Quite pretty, though not what I intended. Some of these blooms got pretty complex and wavy, but most just appeared like the conical cloud of vapor that trails supersonic jets. As the glue rehardened each time, the structural integrity of the cubes was not compromised. If I make another cube, I'm going to test other glues to find a nice clear one that doesn't do this, but still has this kind of strength and fast-drying time (30 seconds or so). It remains an interesting thing to see, however.

Be sure the 6 magnets you glue into the central piece have matching outward-facing polarities.

Step 8: Drill and Fill the 6 Center Face Pieces

These are the pieces that attach to the 6 faces of the central 'axle' piece. They require all but one side to be drilled and filled with a magnet. These untouched sides will be the center facelets on each of the 6 faces of the cube.

Make sure you get the polarities such that these cubes will stick to the center cube!

Step 9: Drill and Fill the 12 Edge Pieces

Now it starts to get fun. The edge pieces each join a pair of center face pieces, and eventually a pair of corners. This leaves 2 faces undrilled, and you just need to make sure these 2 faces connect along one edge.

Again, make sure your polarities work. The two sides that connect to edge pieces need to match - so both N or both S facing out, because a piece can get spun around and return flipped to the same position. Likewise, the corner-facing sides need to match outward-facing polarities, for the same reason. In my model, the edge piece facing sides are opposite in polarity to the corner piece facing sides. This is probably the best way, as I've found that my cube can combine very well in all manner of unexpected positions.

You'll note in the pics that you can now make a central 3x3 layer with 1 central piece, 4 center face pieces, and 4 edge pieces. You can also remove the central piece - something you can't do with a regular Rubik's Cube. Too, you can create the whole cube now, sans corner pieces.

The last pic shows the flexible nature of the layers of the magnetic cube. It's fun to twist it back and forth like taffy.

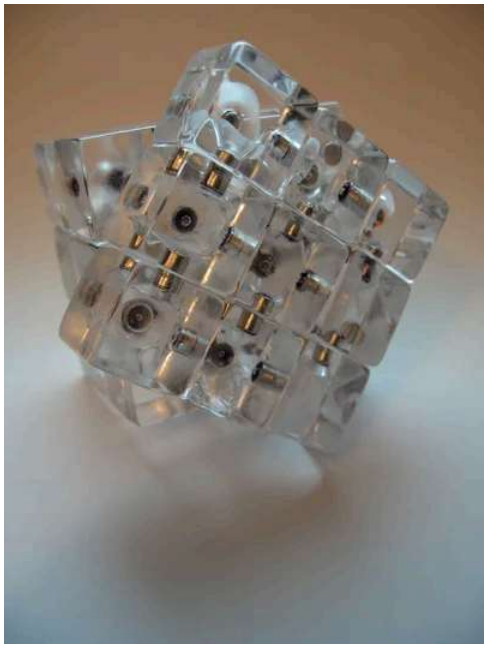
Step 10: Drill and Fill the 8 Corner Pieces



The corner pieces have 3 sides that face out, and shouldn't be drilled, and that means they have 3 sides that should. Just be sure they're all connected at one corner, and that your outward facing polarities all match, and mate properly with the edge pieces.

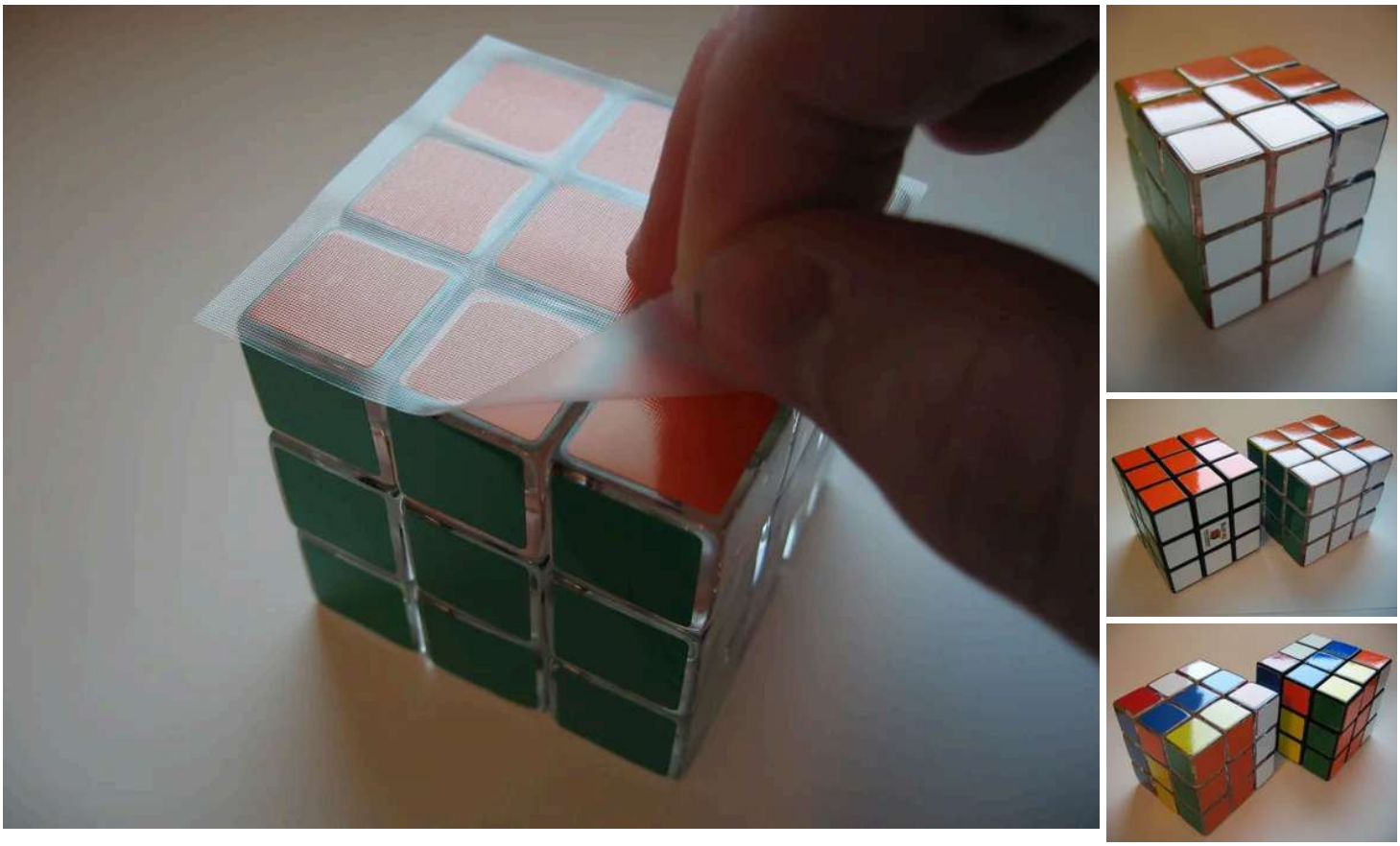
Step 11: Put All the Pieces Together - You're Done!





Now you have a working magnetic cube. It's exactly the same size as an official one, too, but you can make it do many more things, pulling pieces apart, connecting them in new ways, finding weird ways things pivot, and playing with the flexibility of the magnetic connections.

Step 12: Optional Step - Labels!



My newly-acquired cubing habit has not only spawned a bunch of weird project ideas like this, but has also seen me gather lots of official cube junk to me, and as such, I have a stack of nice PVC labels (the polypropylene are crap - steer clear of these immediately-peeling nightmares).

Many people, including me, prefer the beauty of the clear cube, but as this one is my first, and kind of homebrew looking, and because it got boring having nothing to solve, I applied some official labels and made it a real cube, albeit satisfyingly heavier. You really feel you could do some damage throwing this little cannon ball.

The only thing to note here, besides making sure you center them carefully, is that if you want it to be official, you need to put orange opposite red, green across from blue, and yellow on the flip side of white. Also, you need to get the winding order correct. For example, if white faces up (and thus yellow down), and blue faces you (and thus green away), then red needs to be the left face, and orange the right.

Enjoy your new cube, labeled or not, and remember that if you want to apply imagery to the faces of the cube, the edges and corners will always work out again when you solve it, but the centers can end up in 1 of 4 rotations, which greatly increases the number of possible solutions, and makes solving it by traditional methods all kinds of way harder. You can use that to your advantage in a cube with a pattern that can have its subcomponents twist without getting messed up.

Luckily, the magnetocube is easy to take apart and put back together, either way :)