

GEAR CUBE

BACKGROUND

This is not *entirely* an original work. While I did design and build this instance from scratch, much of my own inspiration came from the legions of other papercrafters out there with similar ambitions, as well as the original creator, [Hiraku Nakamura](#). I designed my own for several reasons; partly out of frustration due to a lack of a released parts template (until a short while ago...for the heart version, anyway), partly because the released plan is decidedly more complex than my own (the gears have more of an interior structure, the axles and drive shaft are metal, etc.), and because frankly, this was way more fun than just buying someone else's design. As such, this is in no way a more efficient design, it's simply a guide to how I built a "dumbed-down" version.

This guide was written assuming you've built a papercraft model before, and that you both have the PePaKuRa PDO model file for this project, and know how to use PePaKuRa to help you assemble it. For those of you that **haven't** built a papercraft model OR used PePaKuRa before, I also have an "intro to modeling" guide [here](#) that explains both the basics of modeling and has a big section about using PePaKuRa.

Please don't hesitate to contact me with questions, comments, concerns, worries or wonders. I can't promise I'll respond same-day, but I do try to get back to everyone that reaches out.



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[Deviant Art - billybob884](#)

Disclaimer: I offer no guarantees for this design, your mileage may vary, all sales are final, no refunds, exchanges, or replacements, etc.

NOTE: This version of the gear cube is a not-for-profit work.

If you paid for this, you were ripped off.

TOOLS & MATERIALS

- > Wooden dowels ¹
- > A plastic drinking straw (preferably non-bendy) ¹
- > A cardboard box ¹
- > Regular copy/printer paper of your choice ²
- > A mid-ranged cardstock of your choice ²
- > "Scrap" sheets of cardboard (for "custom parts")
- > Cutting implement(s) - Scissors, Razor, Xacto-knife, etc.
- > Glue of your choice ³
- > Hot glue
- > A ruler or tape measure
- > Optional – Spray paint for the gearbox (color of your choice)

¹ Lengths and diameters elaborated in the section "BEVELED GEAR BOX ASSEMBLY"

² I used 20lbs 75gsm copy paper, and 67lbs 148gsm cardstock

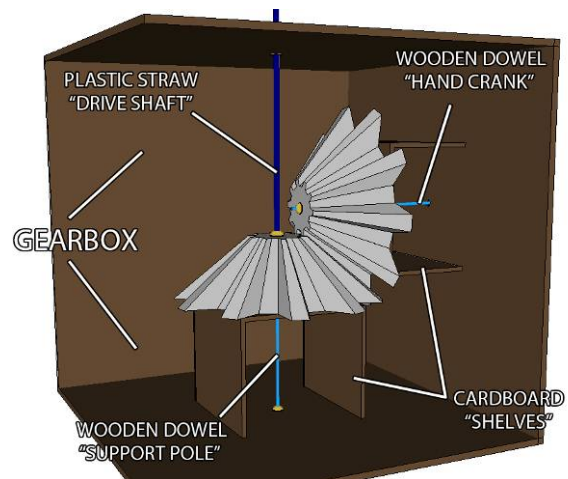
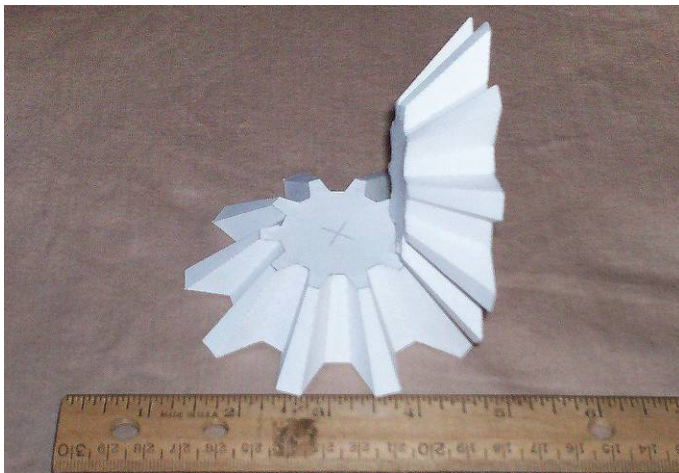
³ Whatever glue you use for models normally; I used Elmer's school glue, but anything will do

PROJECT SETUP

BEFORE PRINTING: I chose to use printer/copy paper for the pieces on pages 01–23, but for the remaining pieces on pages 24–27 I used cardstock. Feel free to use entirely cardstock, entirely copy paper, or some other combination of the two, but the design and instructions are tested written for the aforementioned method.

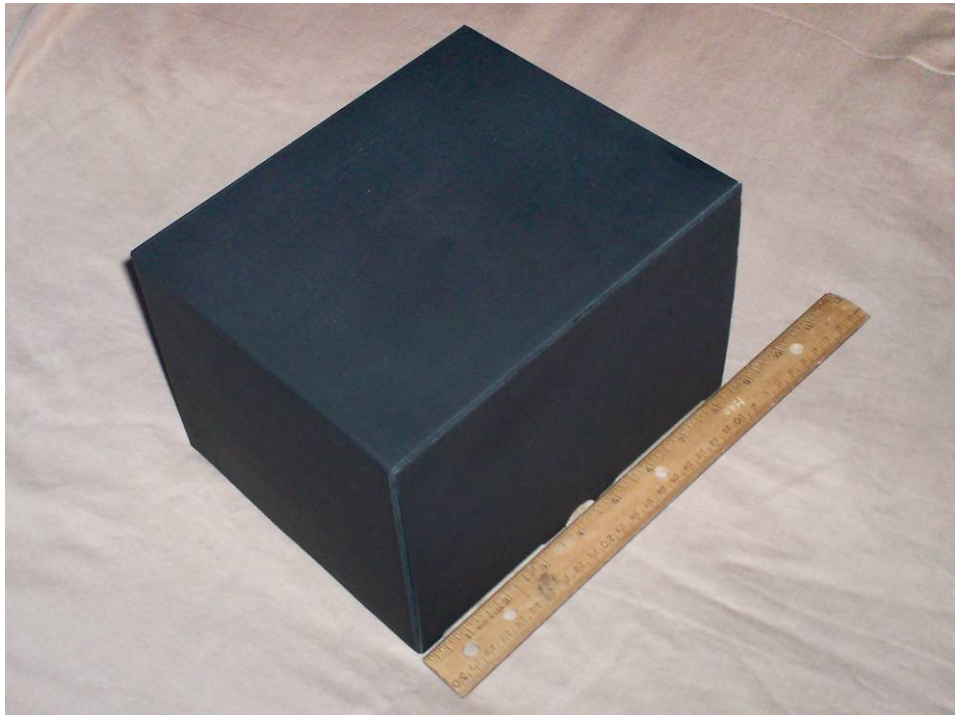
BEVELED GEAR BOX ASSEMBLY

The gearbox is probably the most jury-rigged piece of the whole project and will vary depending on what materials you have available, so you're going to have to get a little creative. First, cut out and assemble the two gears on pages 22–23. These identical (and thus interchangeable) pieces are the connection between the hand crank and drive shaft:



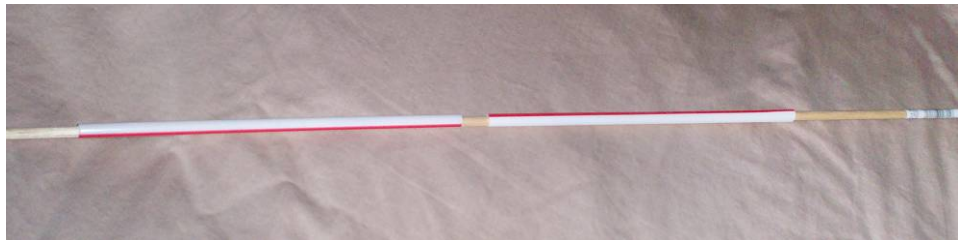
Now you'll need to find a box to use for the gearbox. Note that the above gear setup will fill a minimum space of a 4" (10cm) cube inside your gearbox (not 4in^3 , $4''\times 4''\times 4'' = 64\text{in}^3$), so you'll want to give yourself some wiggle room in all directions, especially if you plan to add something in to weigh the box down. For reference, I chose a box sized 8.5" (21.5cm) wide X 5.5" (14cm) high X 7" (18cm) deep.

I chose to spray paint mine with a flat black primer and let it dry while doing the next step.



Next you'll have to figure out how long the straw drive shaft will need to be. I grabbed a few regular drinking straws I had lying around (measuring about 1/4" (6.4mm) in diameter). For your support pole dowel, you'll want one that fits snugly inside your straw but can still spin freely. The dowel will need to extend from the floor of the box up through the top of the box, then through gear 01 of the actual gear cube you'll assemble later (not shown above), and all the way through the length of the dodecahedron core (not shown above).

To be on the safe side, choose a dowel at least twice the length of your straw drive shaft (all of the straws connected):

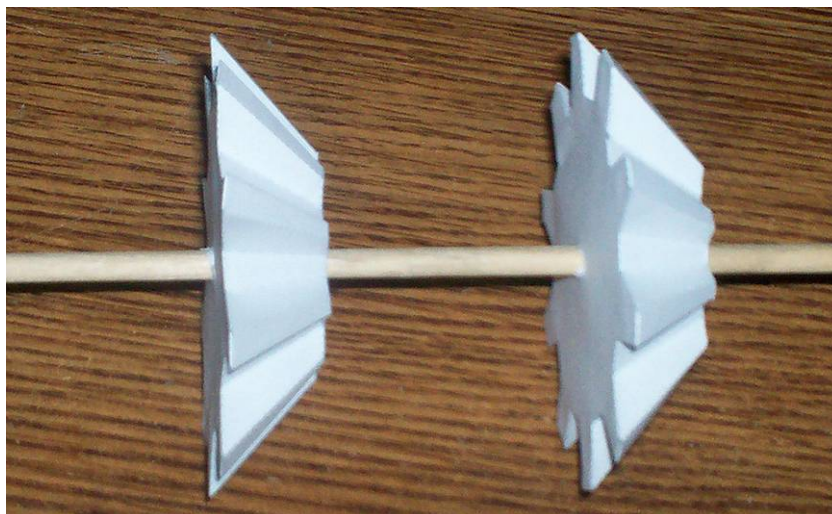


No single straw turned out to be long enough on its own for me, so using a pen, I flared the end of one open further so I could force one straw inside the other, then glued them together. Give them time to dry so you don't accidentally glue them to the dowel.



Note: Depending on how tight your support pole dowel fits the straws, you may need to sand the dowel a little at the spot where the two joined straws will rest to prevent the straws and dowel from binding.

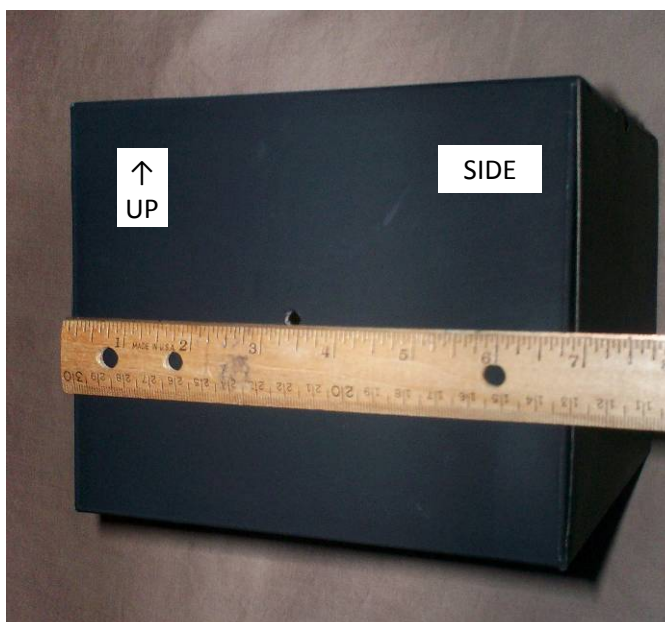
Now, notice the big X's (center marks) on the tops and bottoms of the gears you assembled previously. Use scissors or an Xacto knife to bore a hole through each center mark on both gearbox gears (4 holes, total). You'll want the holes to be just big enough to fit the wooden dowel through, as you're going to be gluing one gear to the dowel, and the other to the straw later.



Jump back to your box. You need to make holes in the box for the drive shaft and hand crank. You'll want the drive shaft holes (one in both the top and bottom of the box) to be centered, so measure diagonally from corner to corner to find your box's centers. Use your blade of choice to bore a little hole first, and then slowly grind at it until your dowel fits through the top snugly. Repeat for the bottom of the box (it should fit very tightly in the bottom, as you will glue this end to the box later).



For the hand crank hole (only on one side of the box, not both sides), you'll want the hole to be horizontally centered, and vertically close to the top of the box while still leaving the gear space to spin. You can center it vertically if you want, but putting it closer to the top will give you more stability in the drive shaft's pole when we add it in later:

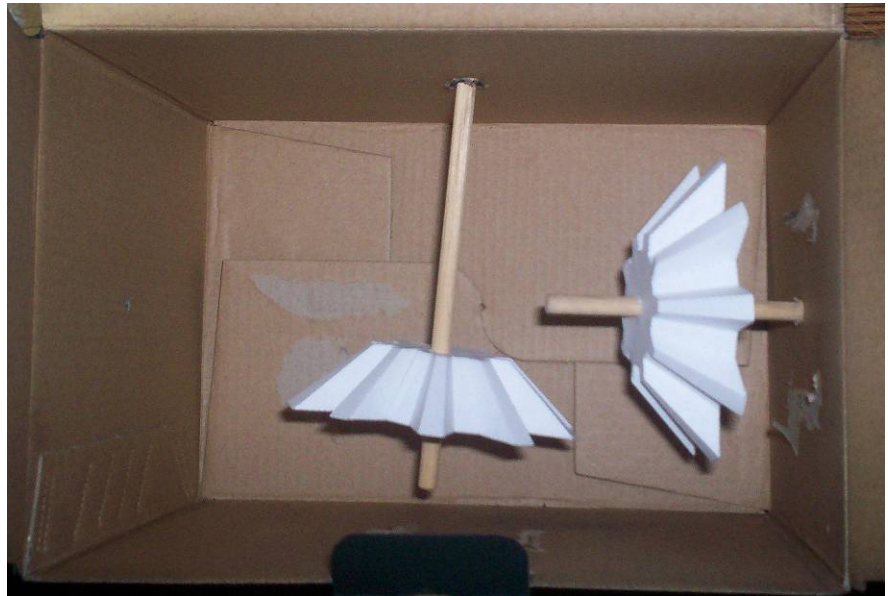


Now, get out your hot glue and cardboard scraps. This is where you'll have to do the most "custom designing" due to your choice of box. Put your dowel through the hand crank hole in the side of the box, and put a gear on the dowel as shown:

Note: Glue NOTHING at this time.

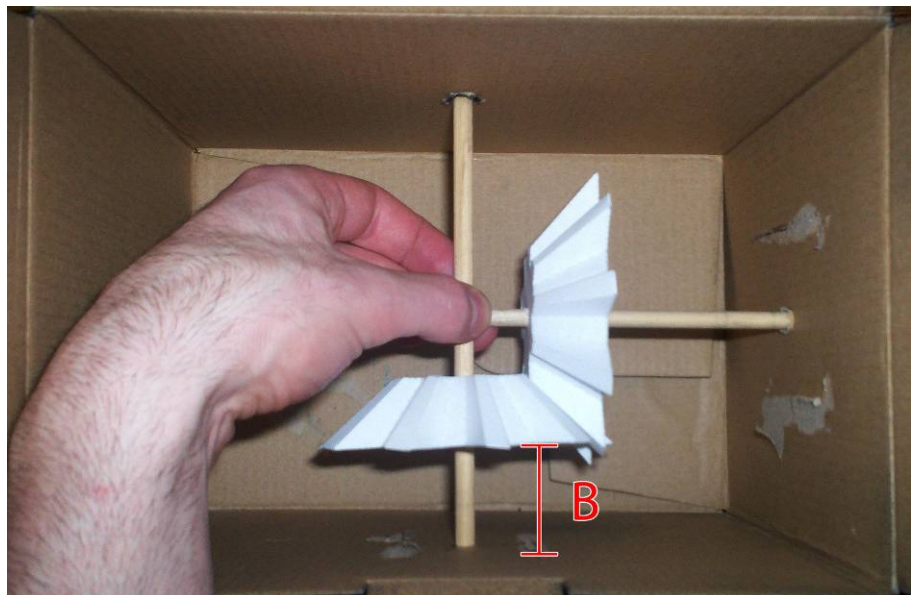


Repeat with the drive shaft's dowel and gear:

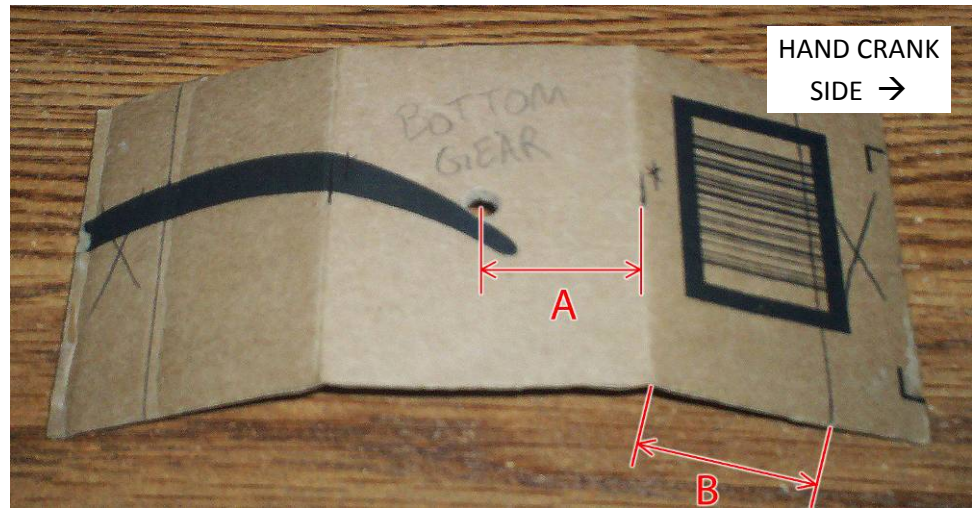


Get a ruler or tape measure handy. Hold the gears by their shafts, level the dowels, and push the gears together tightly to mimic how it will look completed.

Use the ruler to measure the distance "B" between the bottom of the gear and the floor of the box as shown:

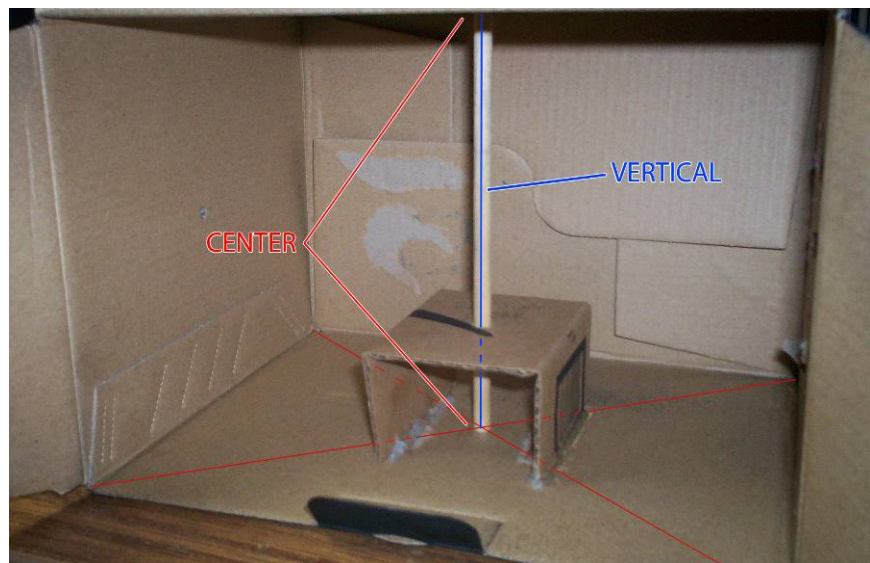


You need to use your scrap cardboard to build two "shelves" for the gears to rest against (as shown in the rendered image at the start). Cut out a long strip of cardboard to bend into a squared "U" shape. Length "B" will be the leg length (on both sides):



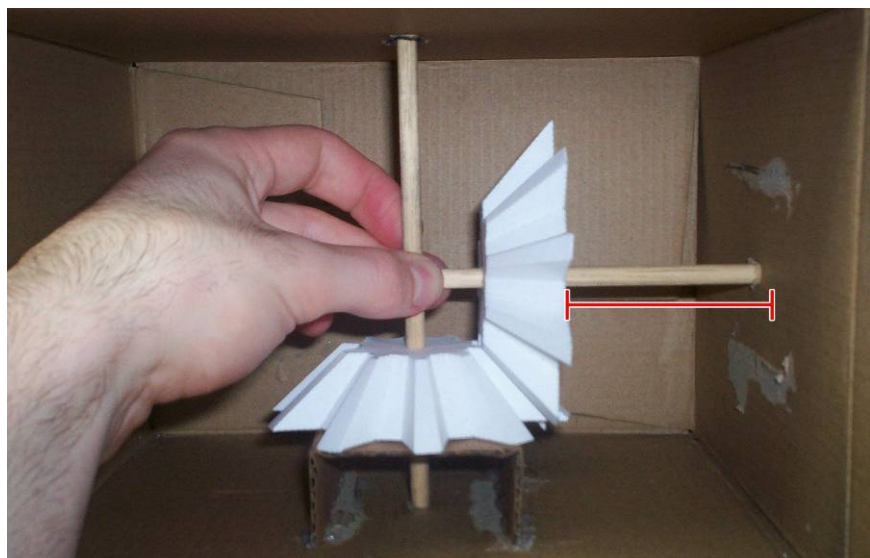
The width of the piece (distance "A") should be NO LONGER than 1.25" (3.2cm) so it does not interfere with the gears. It can extend as far as you like in the opposite direction. The dowel should fit the hole very tightly (the straw will NOT be going through it).

Take everything out of the box, heat up your hot glue, and use just a dowel (no gear) to help you align the cardboard piece (the dowel should be vertically level). Glue the cardboard piece to the inside of the box, but do NOT glue the dowel anywhere (you should still be able to remove it once the shelf is dry):



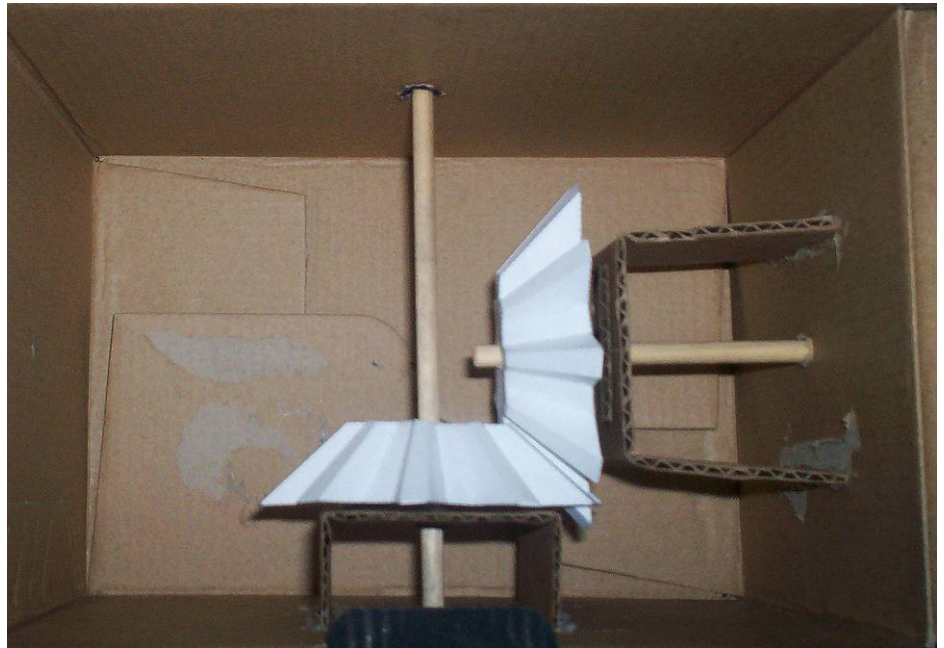
Now, put the gears and dowels back inside like they were on the previous page.

Measure the distance between the right side of the vertical gear and the right wall. This will be the length of your second shelf's legs (i.e. the "new" distance "B")

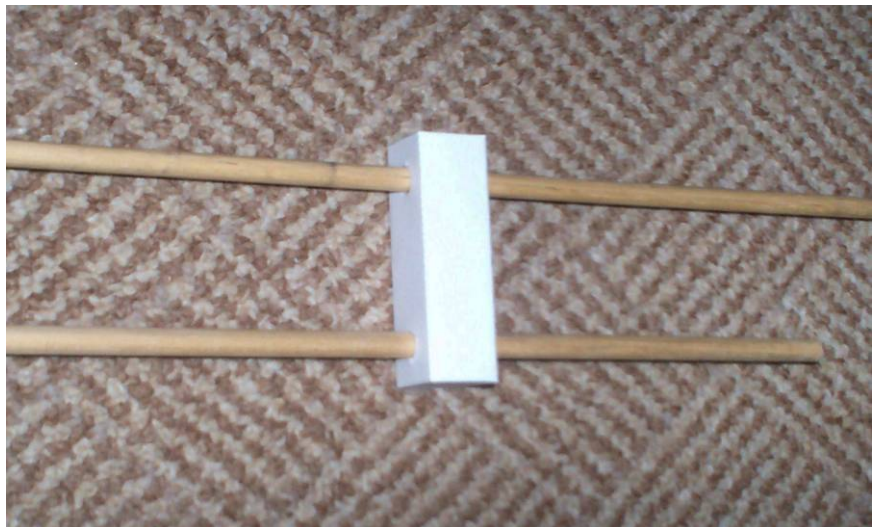


As with the first piece, you don't want to make the shelf's width (distance "A") larger than 1.25" (3.2cm) so as not to affect the gears' connection:

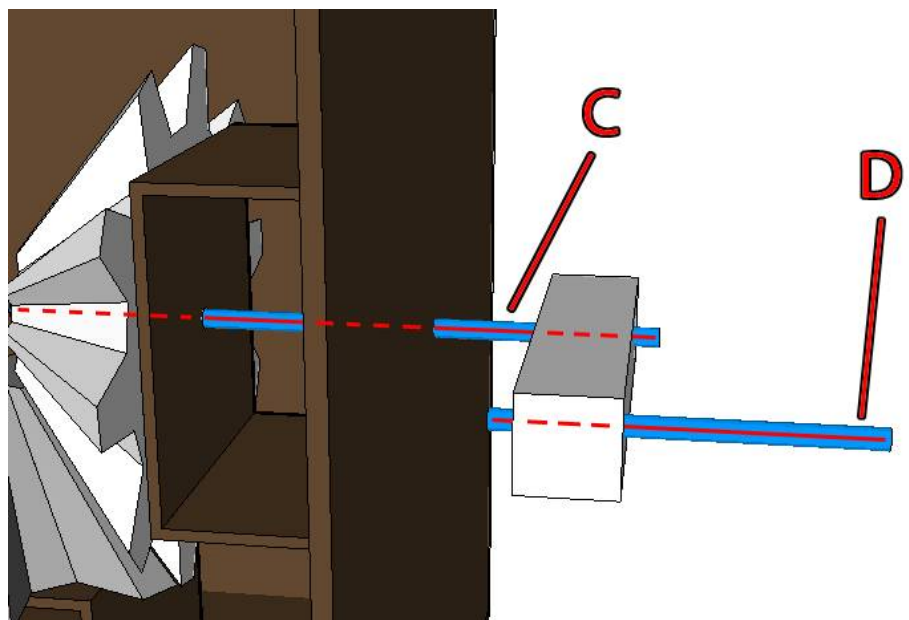
Notice the small extra square of cardboard between the vertical gear and its shelf. I made a mistake and cut the legs too short but didn't realize until after I had glued the shelf in, and was too lazy to rip it out again (I assembled too much without taking pictures for this guide...) and re-make the piece.



Cut out and assemble the rectangular box on page 27. This will be part of the handle. Use your knife to bore holes through the four center marks just large enough for the dowel to fit through snugly.

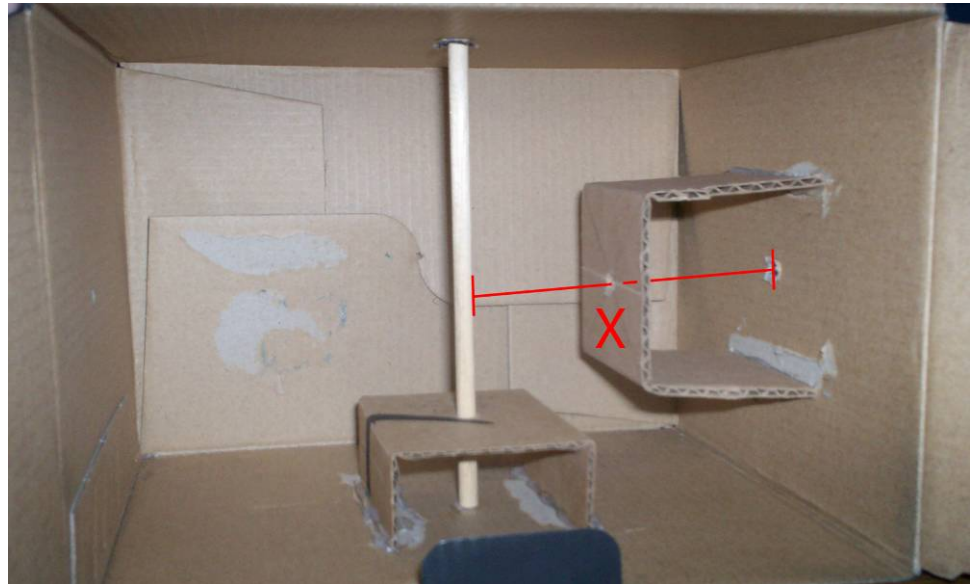


Now to cut the dowels. Piece "C" is the hand crank dowel, and piece "D" is the handle. I used a small fine-toothed cheese saw we had lying around to cut them, and then sanded them down to get rid of the messy edges, but if you're patient enough regular scissors will do:



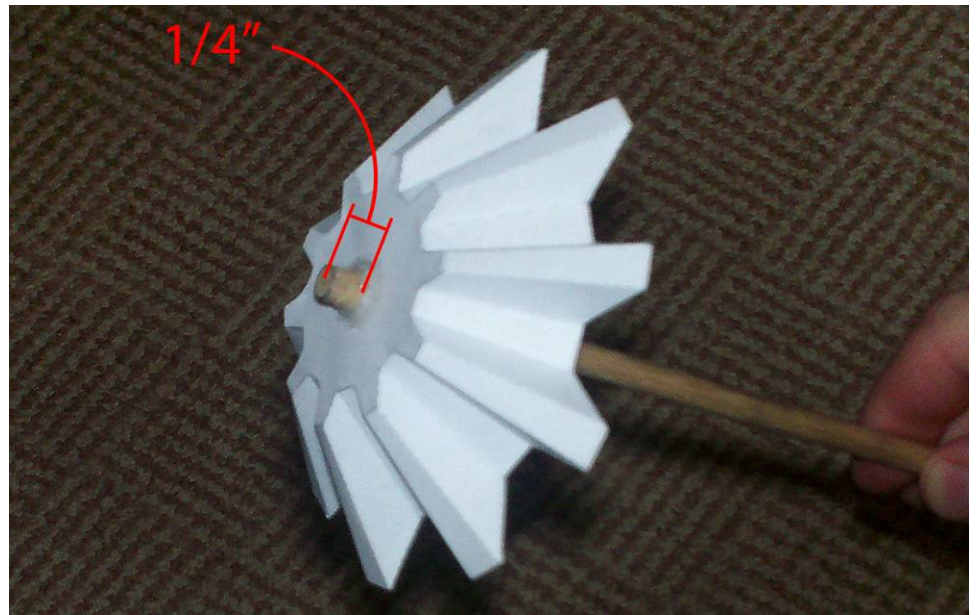
To find the length of piece "C", feed a dowel through the top hole of the box. You want to measure the distance "X" between this pole and the wall where the hand crank will be:

Take this distance "X", add 2" (5cm), and cut your dowel (piece "C").



Now you can attach the first gear. Slide a gear on the end, leaving 1/4" (6mm) of the dowel at the tip of the gear. Don't worry about being messy with the glue on this end, as long as the opposite end is as close to flush as possible (it will rest against the cardboard shelf).

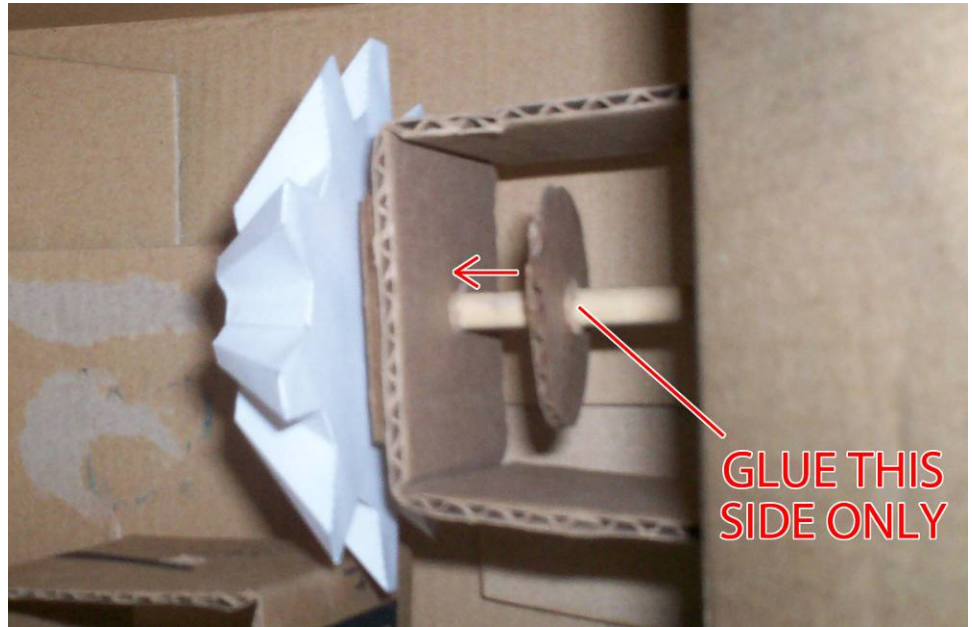
I used Elmer's glue on the back, and hot glue on the tip, but you can mix and match however you please.



Now, grab another scrap piece of cardboard; we're going to make a washer for piece "C". Cut out a small circle that will fit inside of your hand crank "shelf". Cut a hole in the middle that will fit your dowel tightly:

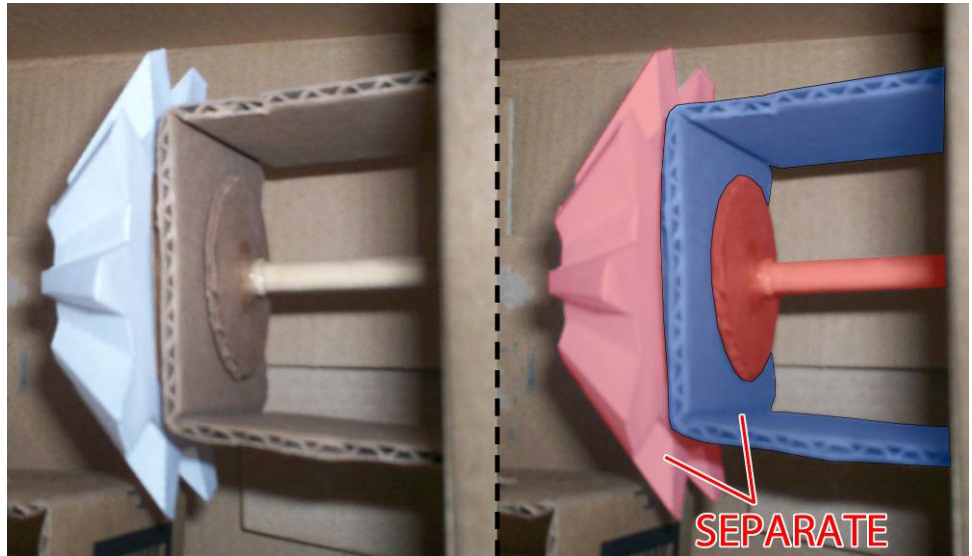


Slide the gear through the box and the washer as shown:

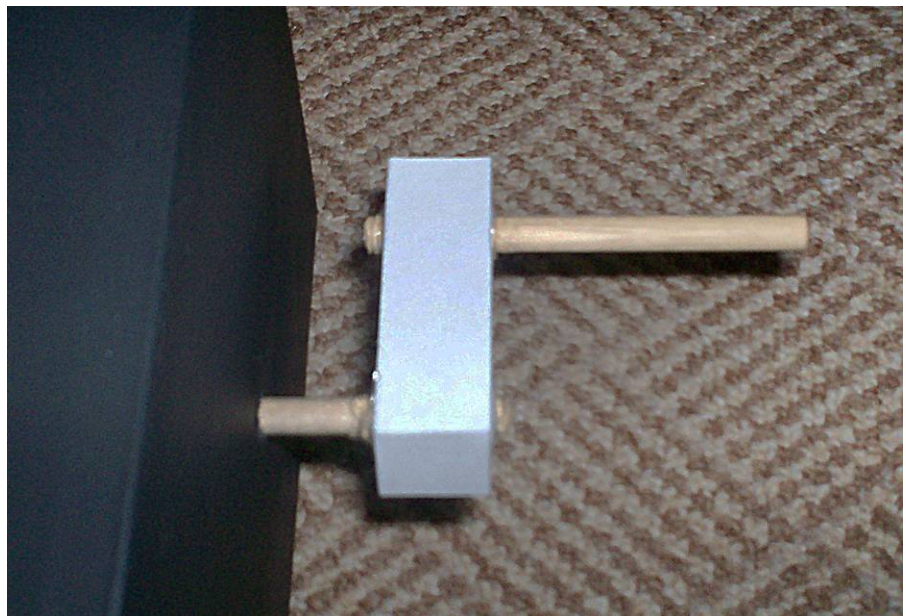


The washer is going to be glued to the dowel but not the shelf. It will hold the gear against the shelf and prevent it from being pushed further in. Press it against the inside of the shelf and glue it to the dowel on just the outside:

Note: When it's dry, you should still be able to spin the dowel freely.



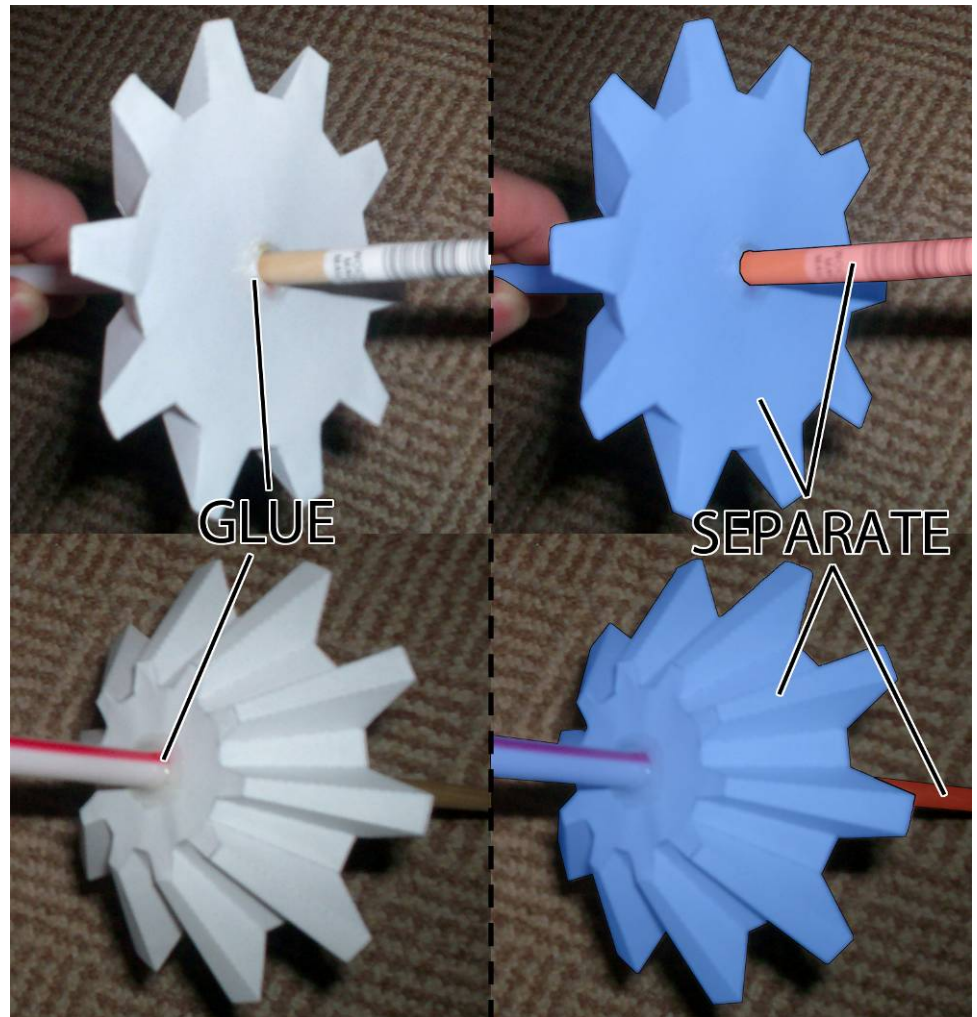
Now back to the dowels. For piece "D", add the width of the box, about 1" (2.5cm), and another 2-3" (5-7.5cm), whatever will comfortably fit your hand. After cutting a length of dowel this size, glue it to one side of the handle box, leaving a small amount of excess on the other size. Once this is dry, you can attach it to piece "C":



Now for the drive shaft.

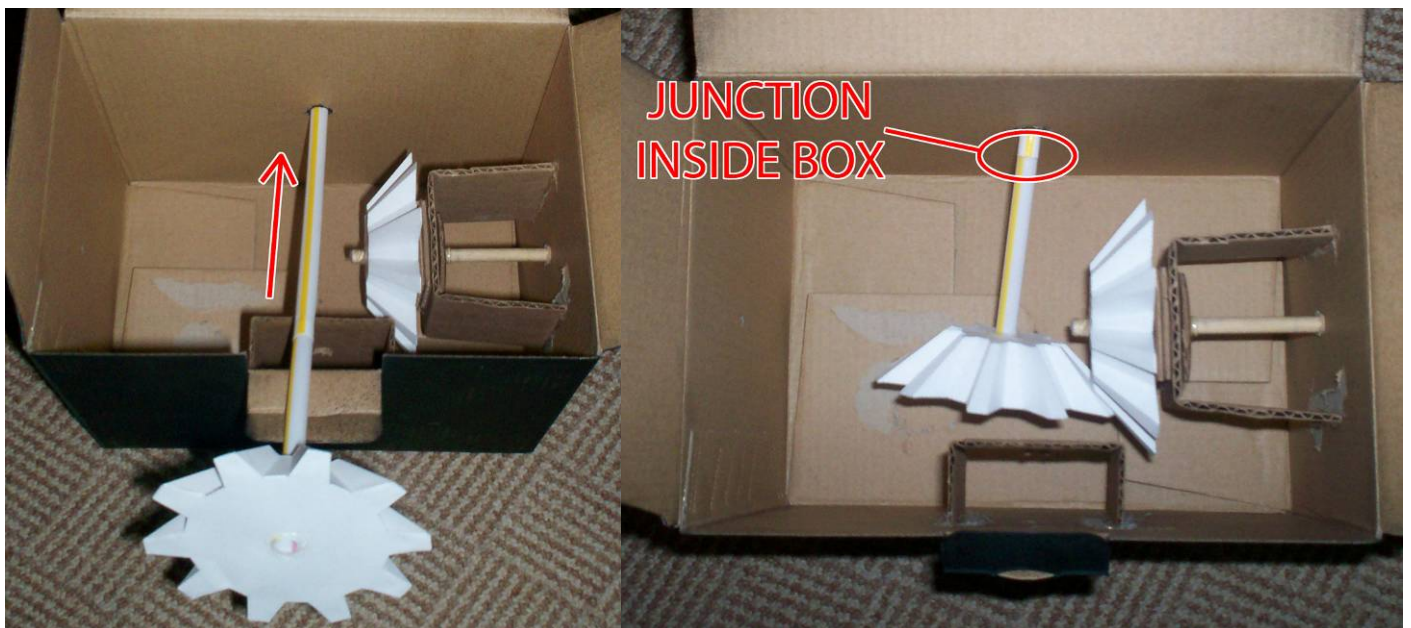
Note: If you plan on painting the straws, you may want to do it now (I did mine afterwards since my box needed a touchup too).

Put the straw shaft through the remaining gear (you may need to widen the holes you made previously). Leave a small* amount of excess at the large end to make attaching it easier (we'll need to cut it off later to make the bottom flush), and glue both ends of the gear to the straw the same way you did for the hand crank:

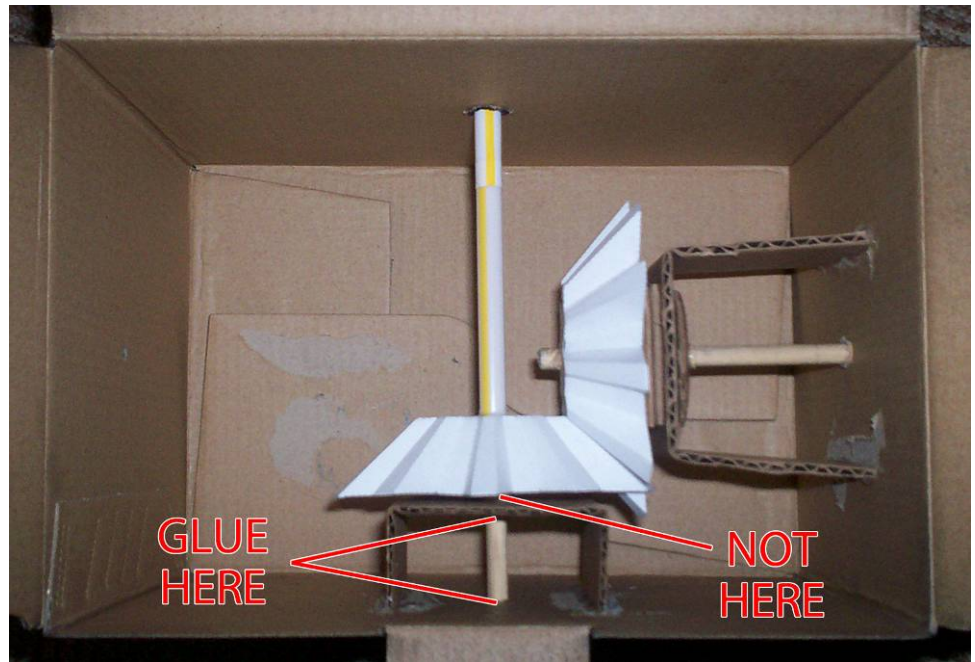


***Note:** If you used multiple straws for the shaft, try fitting the drive shaft in the gearbox before gluing the gear to see whether the straws' junction will end up. I cut off a lot of excess at the bottom to hide the junction inside the gearbox.

After trimming off the excess straw, slide the straw through the hole in the top (without the dowel), starting from the inside of the box:

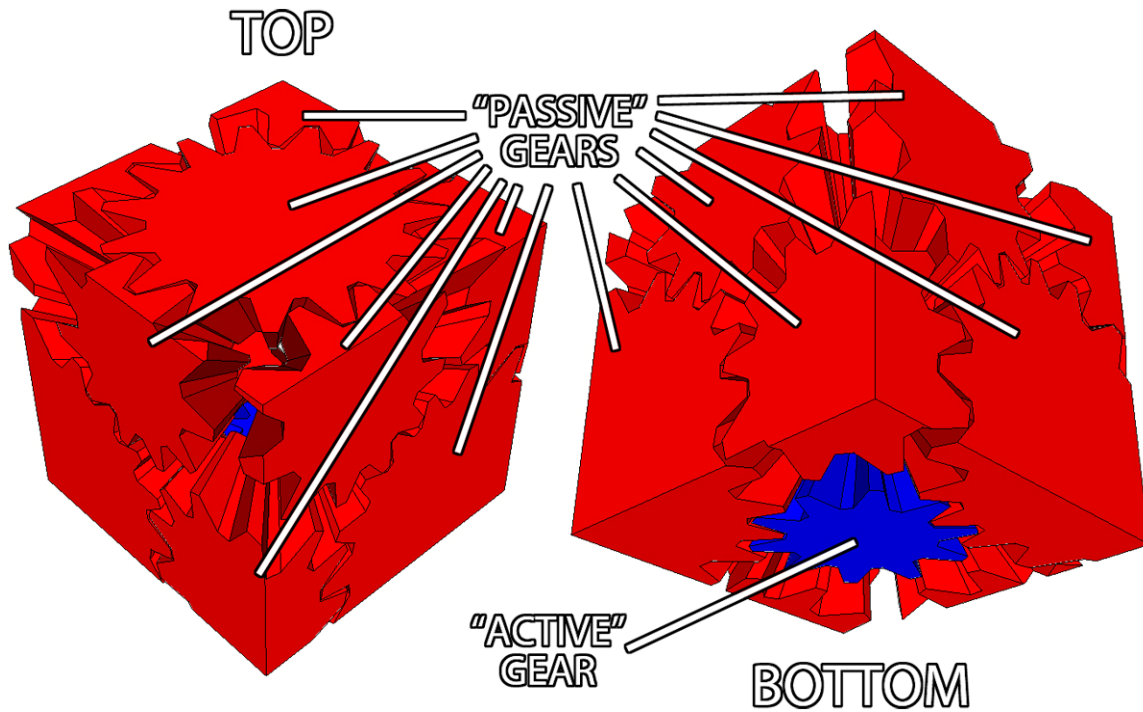


At this point, you should still have at least a good 4" (10cm) of excess straw through the top of the box. If not, you may have trouble attaching the 1st gear of the cube later. Slide another long length of dowel through the top of the straw drive shaft, down into the box:



Now you'll want to glue the support pole dowel in place. It will attach to the bottom of the box and optionally the shelf (for extra stability), but not to the straw drive shaft (it should still spin independently, as shown above). Once dry, you should finally be able to turn the handle and have it spin the drive shaft.

With this complete, we can turn our attention away from the gearbox for the moment.



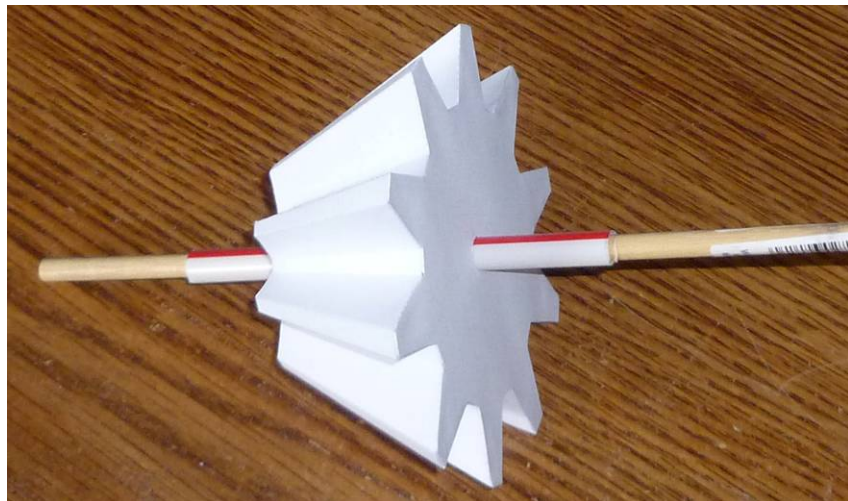
GEAR ASSEMBLY – 1 "ACTIVE GEAR"

The sole “active” gear, shown above in blue, is the easiest out of all 12 gears you need to build, as it doesn’t need the special axle added in that the rest will later on. Cut out the pieces for gear 01 from pages 20–21. This is straightforward to assemble, just like the two gears for the gearbox. Use the PDO file to help you if you need it:

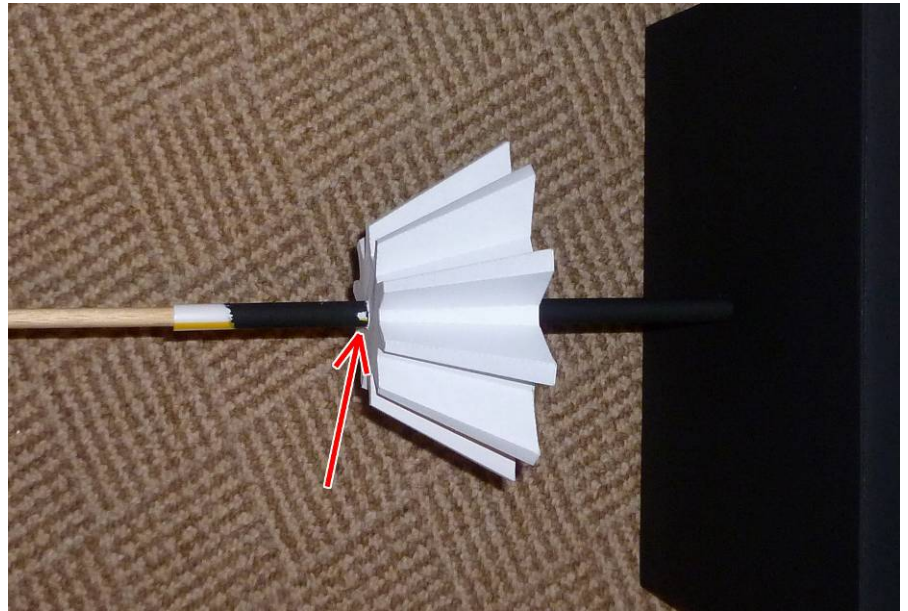


Now we’re going to attach it to the straw drive shaft. Cut holes big enough for the straw to fit through on the two center marks at each end:

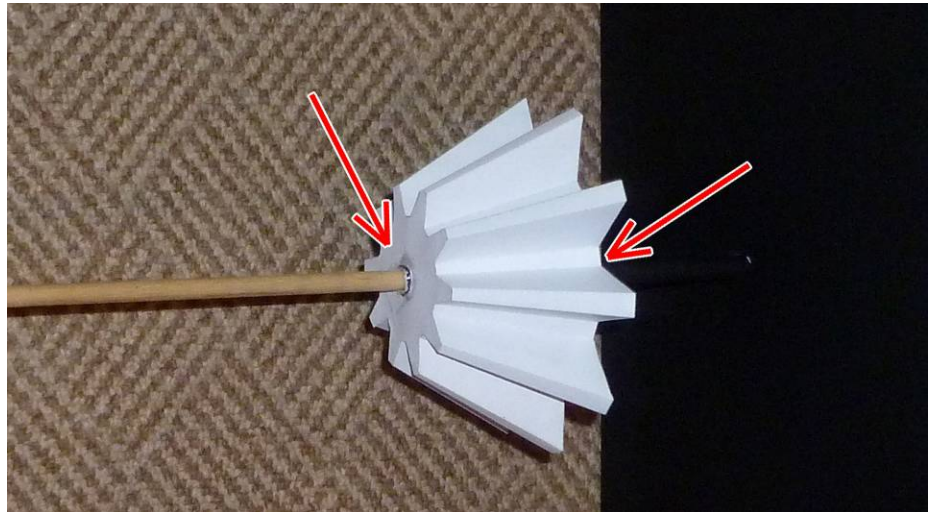
Note: The straw in this picture is just a small piece of extra I had left over from before.



Slide the gear onto the straw drive shaft. There is no specific height it needs to be at, but it should be at least a few inches above for the other gears to be able to spin (mine is attached 3" (7.5cm) above the box). Choose the height you want to glue it at, keeping in mind the bottom face of this gear will be the bottom plane for the final gear cube. Once you have your height, mark your cutting line on the straw at the top of the gear. I scratched a little of the paint off the straw, but whatever works for you.

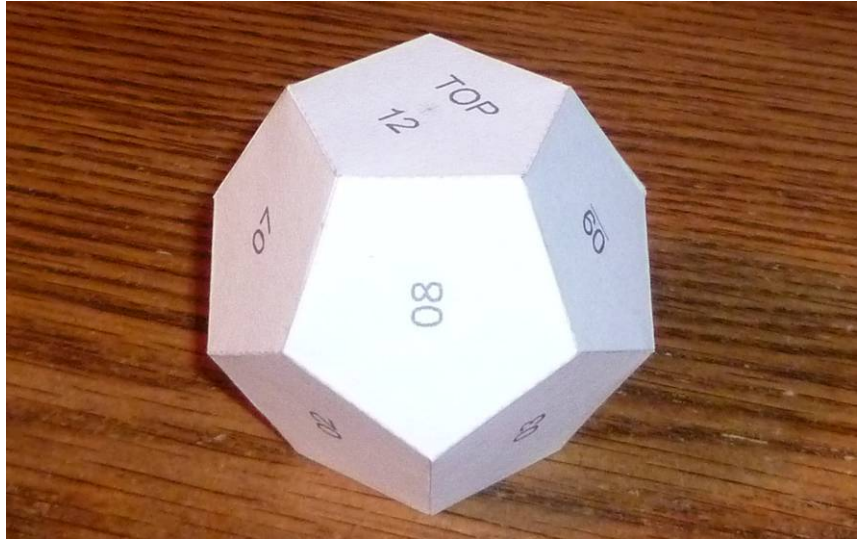


Remove the gear from the straw and cut off the excess straw at your mark. Replace the gear, and carefully glue the gear at both the top and bottom, just like we did for the second gear inside the gearbox:

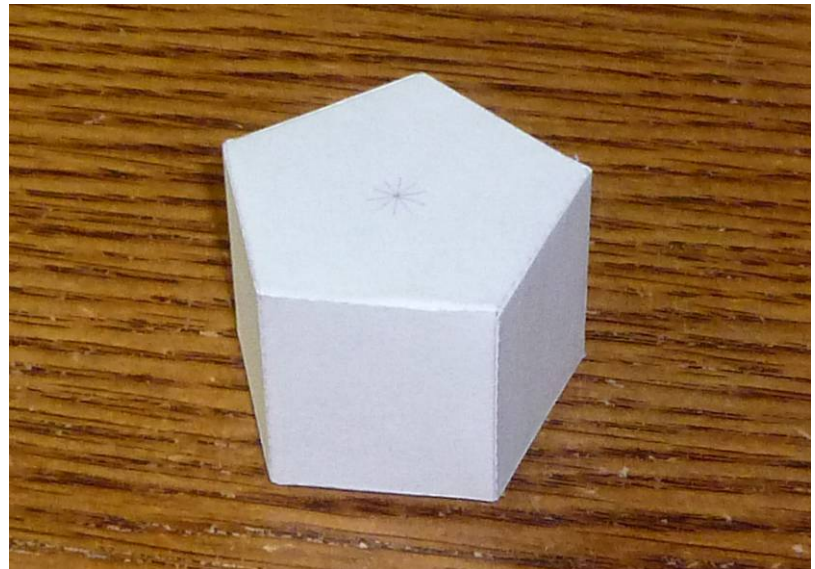


CORE ASSEMBLY

Cut out and assemble the dodecahedron (12 sided) core on page 27 (you should have printed it on cardstock, as it will need the extra strength to support the other gears later):

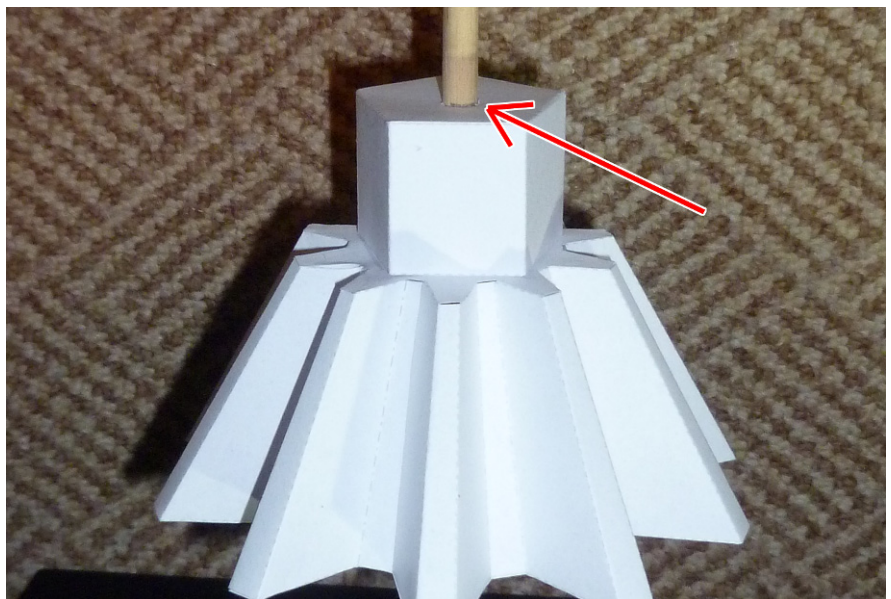


Bore holes through the top and bottom just large enough for your wooden dowel to fit through tightly, as we'll be gluing the core to the support pole shortly). Before we can attach the core however, we need to figure out how high to put it. Cut out and assemble one of the 5-sided "pentagonal" tubes on pages 24–26. Once more, bore a hole through the center mark on top (not shown) big enough for a dowel to fit through and spin freely.



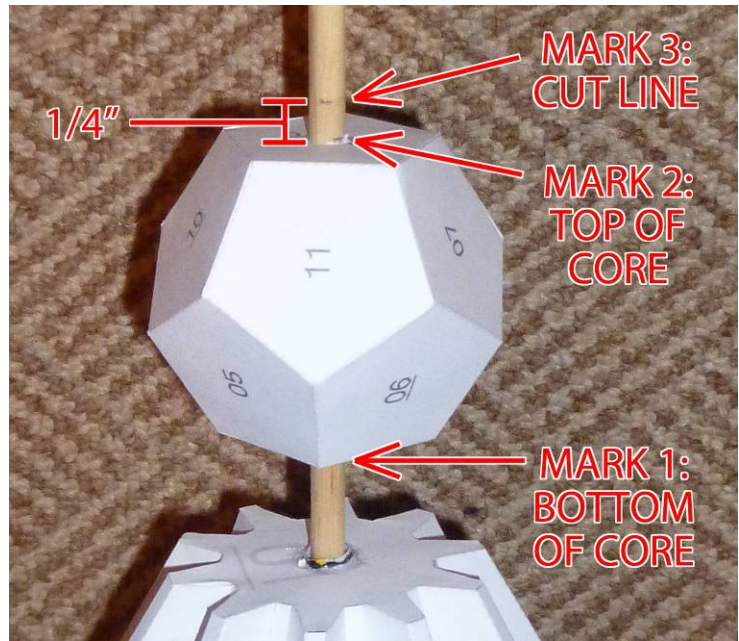
For the gear you have already attached to the drive shaft, you won't actually need this piece to act as an axle; you'll only be using it as a ruler. Slide it down the support dowel so it rests against the top of the gear as shown.

Make a mark on the dowel at the top of the tube so you know how high to attach the core. Remove the pentagonal tube and slide the core onto the support pole, aligning the bottom with the mark you just



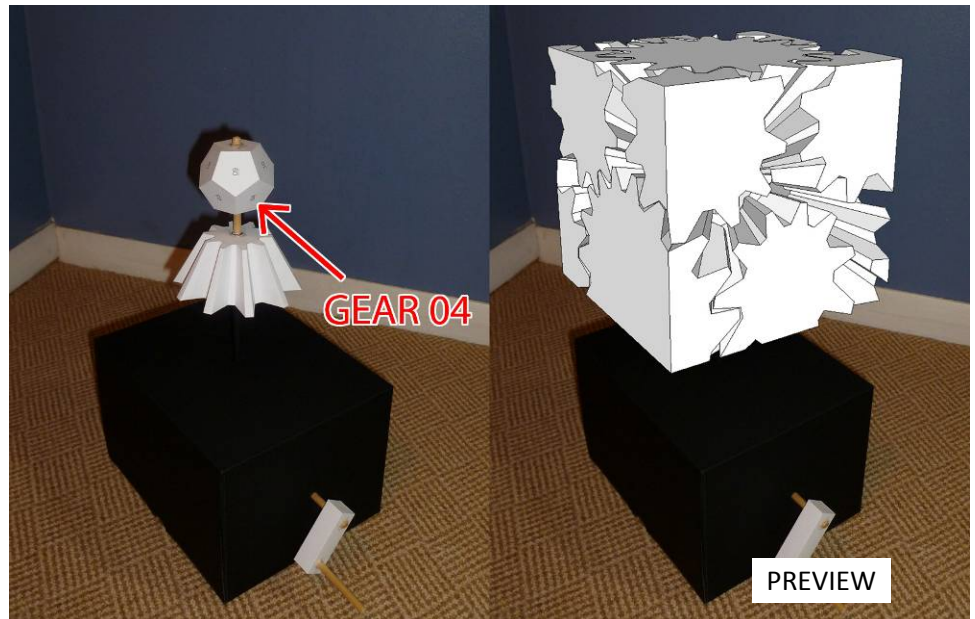
Make a mark at the top of this core, and then another about 1/4" (6.4mm) above. This second upper mark will be where you cut the dowel.

Take the core back off, and cut the dowel along the top-most mark you just made. After this, you can attach the core.



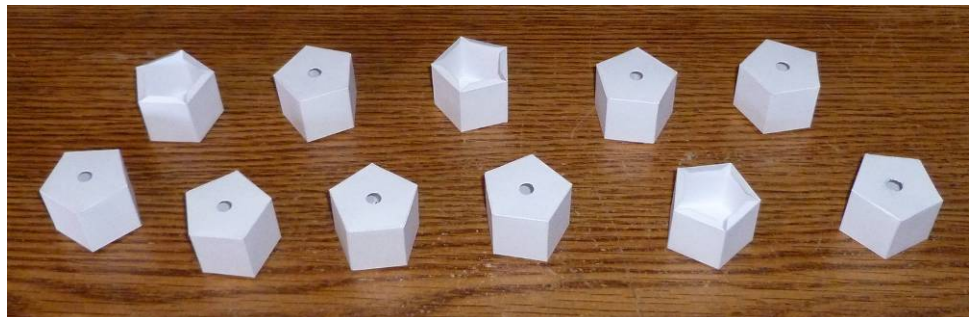
Before you do however, you need to choose its orientation. I chose to use the side with gear 04 aligned to the right of the gearbox (the hand crank side), but you can choose any face.

Use the PDO to help you decide which you like best (the faces of the core are numbered). Slide it back on the dowel, aligning it with the two remaining marks on the dowel, and glue at both the top and bottom, preferably with hot glue:



Before jumping to the remaining 11 gears, you may as well get the rest of the tubes out of the way. There are a total of twelve included, minus the one you already assembled, but you'll only need eleven since the one gear you've already attached under the core doesn't need one. Assemble ten more of the eleven remaining, and make holes in their tops the same as you did to the first:

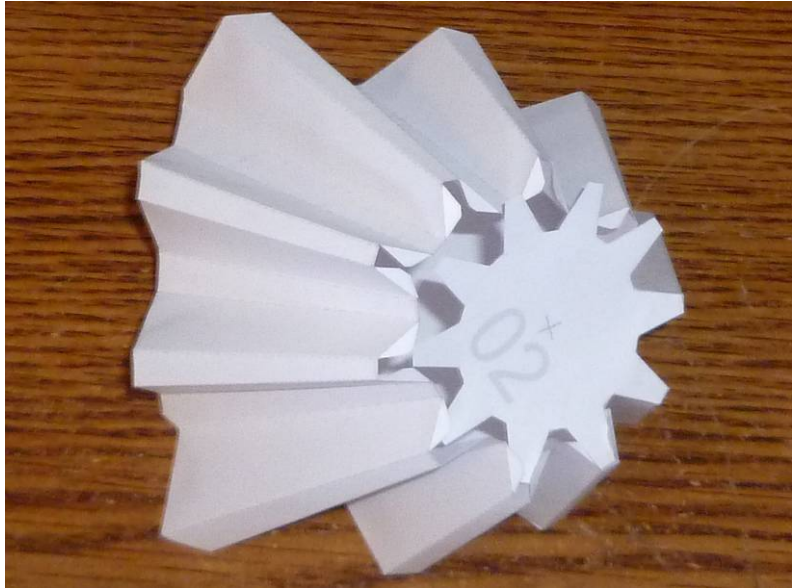
You'll need these later while assembling the gears.



GEAR ASSEMBLY – 11 "PASSIVE" GEARS

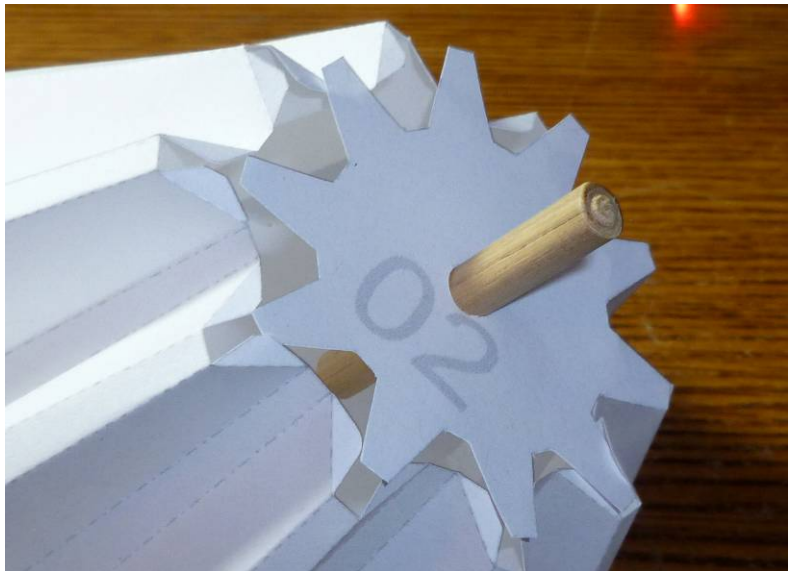
This is by far the most tedious part of the project. You need to repeat this section eleven times total since there are eleven gears, and they vary in size and complexity.

Since you're going to need to attach an axle to the smaller "inner" face, my recommendation would be to start from the larger, square outer face and work your way inward. The side facing the core should be attached last, only once the axle has been inserted. Stop when you get to this point:



Now, carefully bore a hole large enough for your dowel through the center mark on the smaller "inner" face you left mostly unattached.

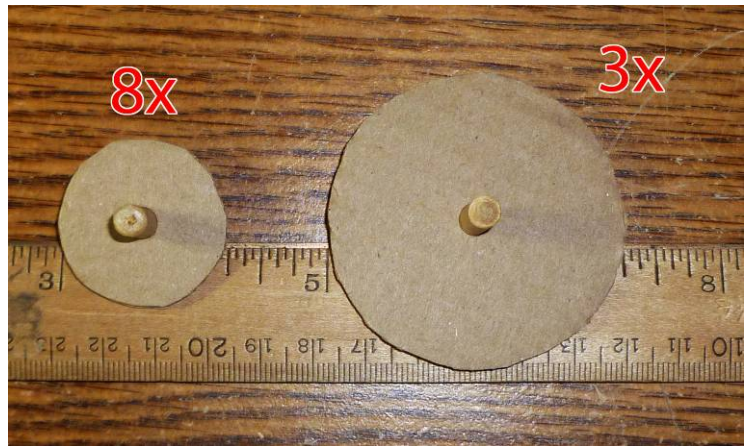
Note: For future reference, it's easier to cut the hole BEFORE attaching the back face... I found this out the hard way.



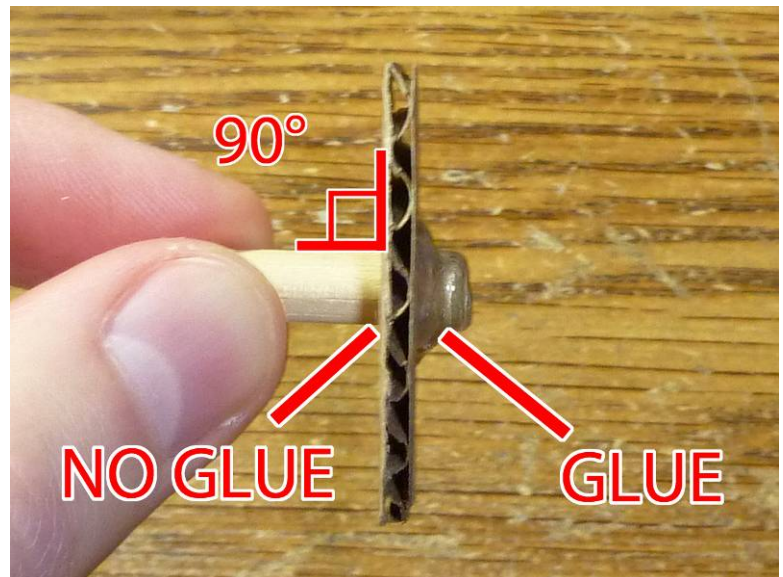
Get out some more of your scrap cardboard and a long length of dowel; we're going to make a bunch of axles and washers like the one we made for the gearbox. You'll need eleven of each. The dowels should be sections about 1" (2.5cm) long:



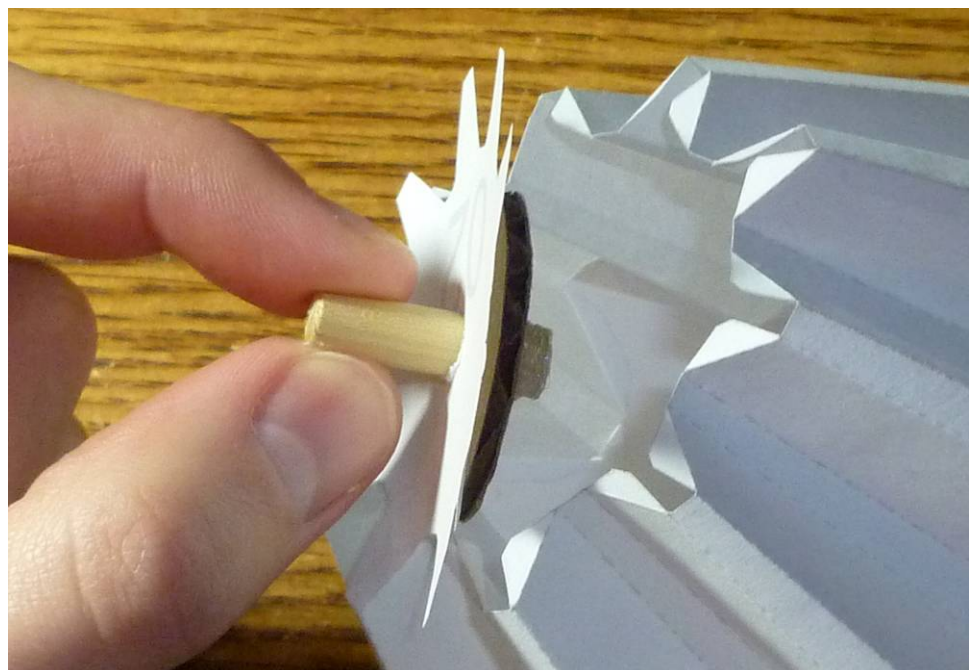
...and 8 of the washers should be about 1 ¼" (3cm) in diameter, and the other 3 should be 2 ¼" (5.5cm) in diameter. The large discs will be used in gears 03, 06, & 12, while the rest will get the smaller discs. Cut a hole in the center of each big enough for your dowel to fit tightly, as we'll be gluing one washer disc per dowel piece you cut earlier:



You want to glue a dowel through the center of each disc, leaving roughly 1/4 of the total length hanging out on one side. I would recommend only gluing the disc on the side with the short amount of dowel. Try to align the discs as close to perpendicular as possible:



Once dry, take one and feed it through the hole you made in your first gear, so the large portion of the dowel is poking outside the gear, and the disc is inside:



Clip a paperclip or something on the outside to temporarily keep it from sliding all the way through and getting stuck inside the gear while you finish closing the inner face:

Note: The dowel should spin freely in its hole.



Take one of the pentagonal tubes you made a little while ago, remove the paperclip from the gear's dowel, and carefully feed the dowel from the gear through the tube's hole.

You want to glue the dowel to the tube (on the inside of the tube is easiest) so the dowel and tube are joined, but the gear is independent. Hold the whole rig by the dowel (using pliers makes this easier) and allow the tube to rest flat against the inner face of the gear:

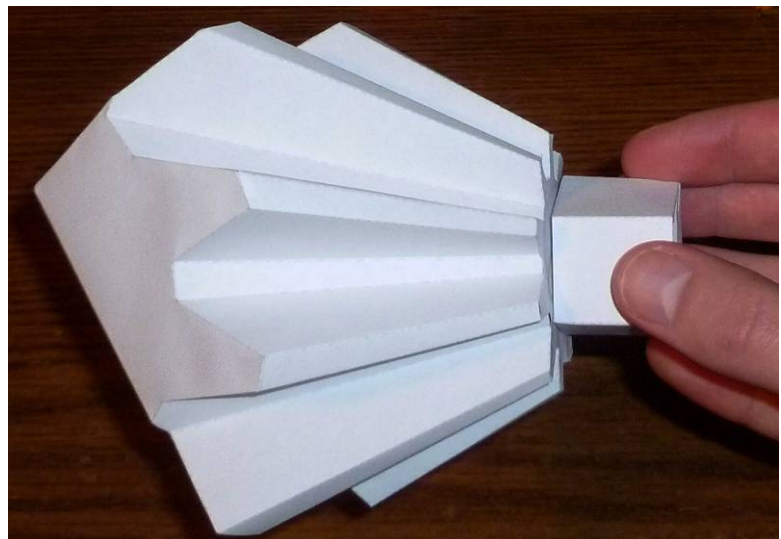


I recommend hot glue for attaching this section, as it's less likely to leak through the tube's hole and accidentally glue the two sections together.

Once dry, you should be able to hold the assembly by the tube and have the gear stay close to flush with the tube:

If you used lighter paper and not cardstock for the gear, this should be less of a problem for you.

Note: It's a good idea to write the gear number on the side of the tube. You'll need this number later to attach them to the core.



Rinse and repeat for 10 more gears:



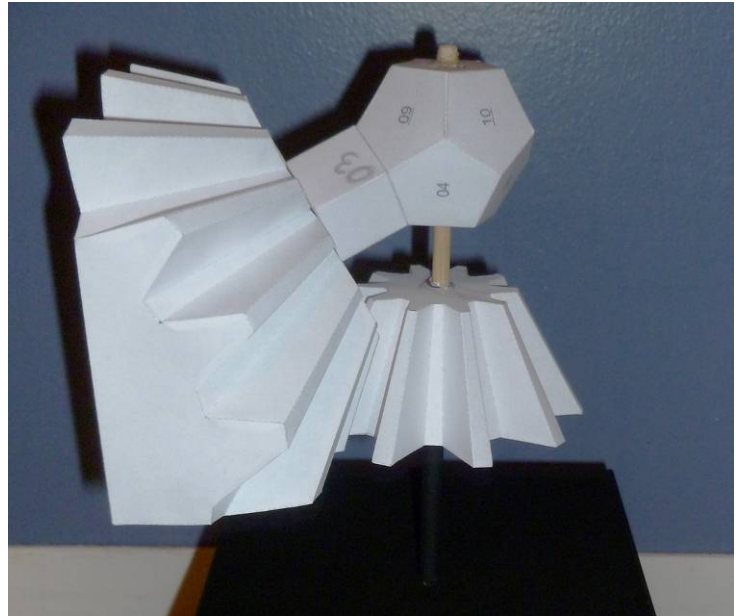
FINAL ASSEMBLY – ATTACHING THE GEARS

You're in the home-stretch!

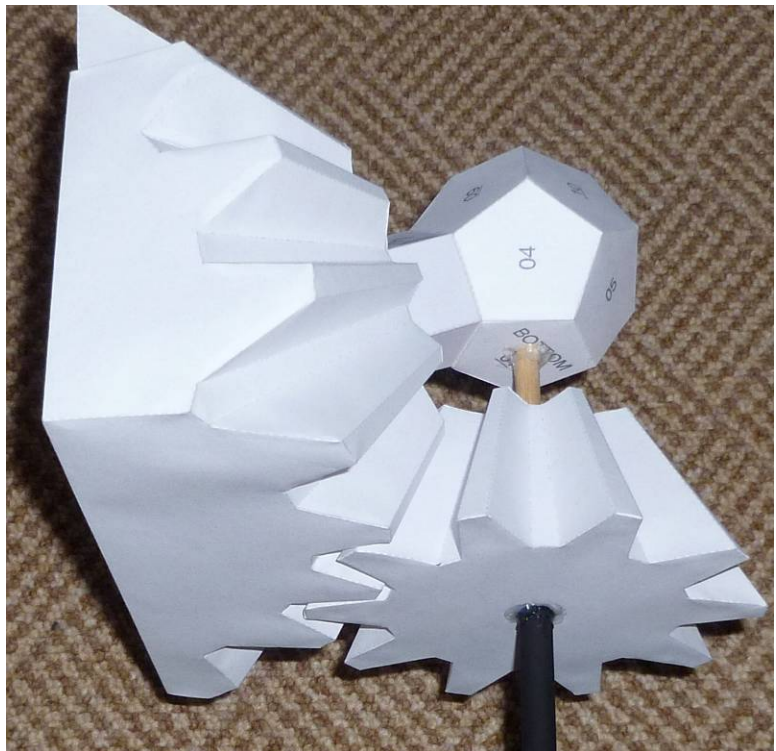
This part is a little tricky, as you need to orient each gear while attaching it to the core. Hopefully you continued to number the axles as you built the gears, otherwise you'll need to try to compare each to the PDO model to figure out which is which.

It's easier to start from the bottom and work your way to the top, so I recommend starting with the two big pieces, gears 03 & 06:

Note: gear 06 is not shown here; I only attached gear 03, and had a tough time attaching 06 after 02, 04 & 05.

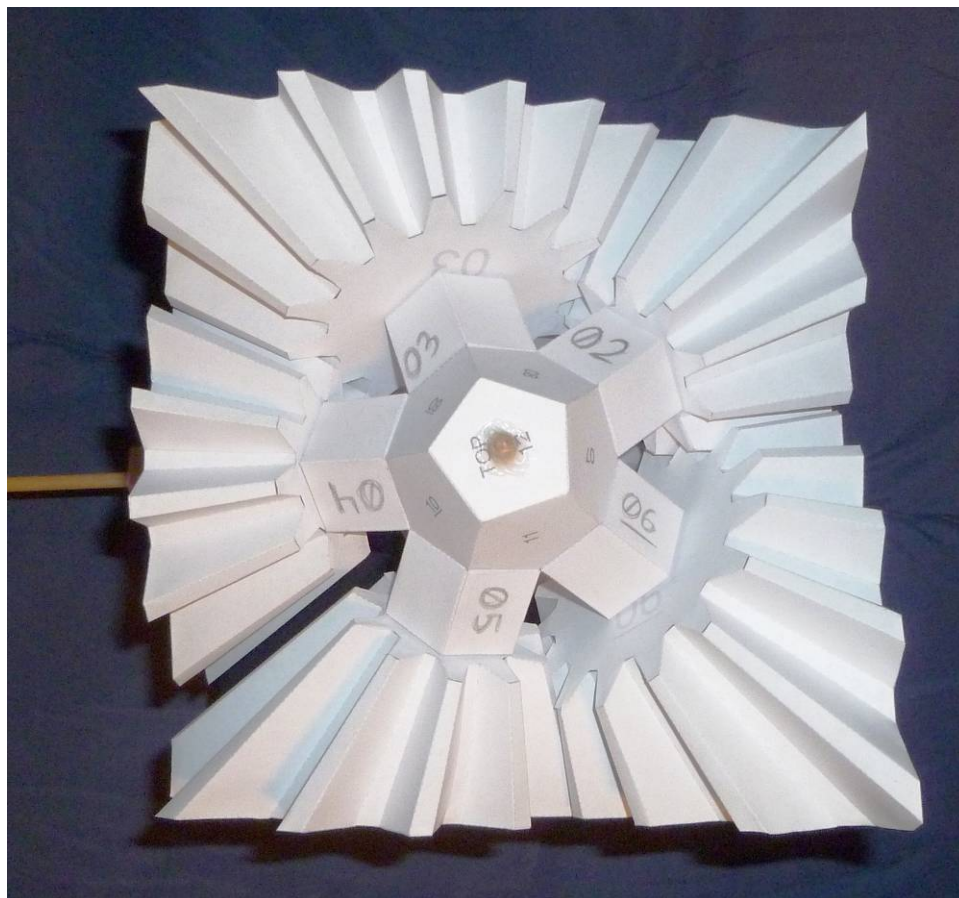


The bottom of both gears should be flush, with a gap about this size between them:



Continue with gears 02, 04 & 05. Use the PePaKuRa model to help you orient the gears while attaching them, since they will be difficult to adjust once attached. Allow plenty of time between each gear for the glue to dry.

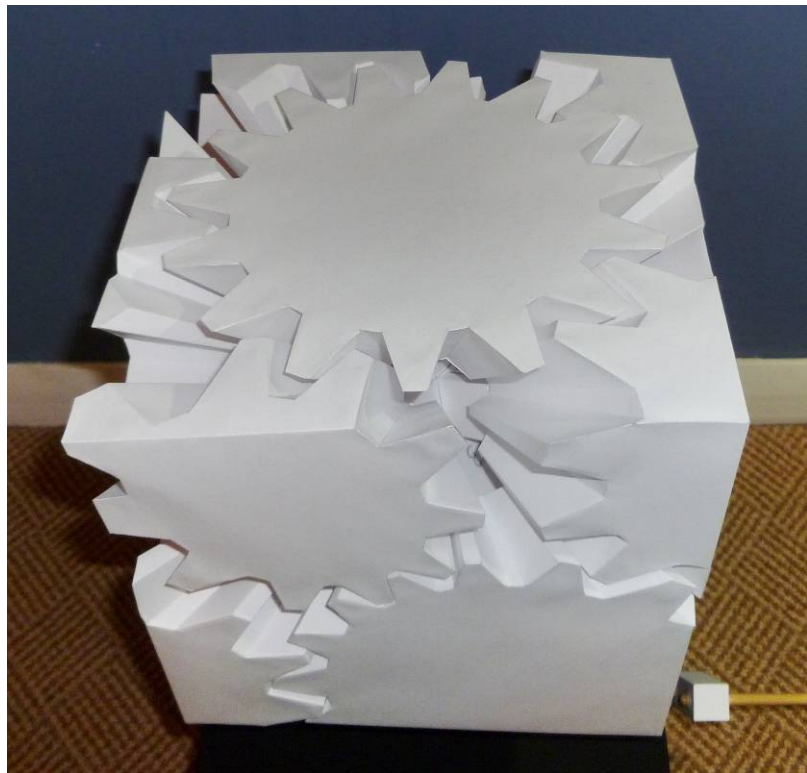
Half way there!



Since the only other big piece is gear 12, which sits on top, leave it for last. You can attach the remaining gear 07-11 in any order you please.



Finally, you can attach the last gear.



Et voilà! Zé masterpiece, she is complete! Cross your fingers, give that baby a crank, and see what happens!



CONCLUSIONS

Assuming it works and all is right with the world, you may want to consider a little finishing touch. In my case, my gearbox ended up being pretty light, since it was only cardboard. So I added in a whole mess of old bolts we had lying around to help give it some ballast. Thankfully the box was roomy enough to accommodate the extra pieces:



And you should be done! Hopefully you've had fun and will walk away with a finely crafted piece of mechanical-paper technology!.. or, you know, a neat little paper model... But in any case, thanks for building!