1. User Manual

Hello User! When you first receive your TidyTwist, it will already be put together, but you will need to fill each 3.4oz container with the liquids of your choice. To do this, you need to disassemble the TidyTwist.

1. Unscrew the bottom lid and take it off the main casing

2. You will notice a central rod that pokes out of the bottom of the casing. Take the screw out of the bottom of the rod and put it to the side. Do not lose this screw!

3. You should now be able to fully unscrew and take off the top lid, which you should do.

4. Now, you can easily reach into the casing and take out the tray holding the four 3.4oz squeeze bottles.

5. Pop the 3.4oz bottles out of the tray by applying force to the black lids. You can now fill each bottle with whatever liquid you want.

6. Reassemble your TidyTwist following these steps but in reverse. Happy traveling!

2a. Design for Manufacturing:

Our product is comprised of many parts, the majority of which are either vendor-bought or 3D printed. The main body of our prototype, comprised of the custom-made Top cap, Bottom cap, Outer case, Four-bottle holder and Inner rotatable part are all 3D printed from PLA material. This is not feasible for mass manufacturing purposes since the production of the 3D printed parts currently costs more than 200 dollars, and increasing production to 100+ parts would make the costs of production extreme. In addition, 3D printing takes a couple of hours for our parts, so the process is not ideal. Other manufacturing methods to create these parts, such as injection molding, would decrease costs per unit despite initial costs for equipment and setup, and would also maintain material strength and increase efficiency since the time to manufacture each part would decrease. For this reason, we have decided to use injection molding to manufacture all our previously 3D-printed parts.

Manufacturing Process for Parts:
Top cap - Injection molding
Bottom cap - Injection molding
Outer case- Injection molding
Four-bottle holder- Injection molding
Inner rotatable part tray & Center Rod - Injection molding
Stretchy Band - Vendor Bought, not manufactured
Rod inside Center Rod - Vendor Bought, not manufactured

Modifications:

I modified the top and bottom caps to have fillets to make the design more suitable for injection molding. I also added parting lines to these parts that would be for injection molding in the fusion files, specifically the bottom and top cap via a construction line. I also edited the liquid bottle tray, labeled as the “Tray” part in the Inner Rotation Part File, to make the overall shape a rounded square rather than a “flower” shape to improve the shape of the mold.

2b. Design for Assembly:

The assembly of our product is relatively simple, with a rotatable tray, a center rotator, and a central rod that goes into a large outer shell, and two lids with threading that the users could easily identify where they should go onto the bottle.
In terms of assembly clarity for users, we believe that we have design merits that could guide the user to better assemble and disassemble the product easily. Specifically, we implemented a poke-a-yoke technique in the rotatable tray, center rotator, and bottom of the outer shell — two little cylindrical joints stretching out of the center rotator and corresponding notches on the rotatable tray and bottom of the outer shell. In this way, the user could clearly see how the joints should be aligned and injected into the rotatable tray from the bottom of the outer shell. However, confusion in assembly might still arise when the user needs to insert the tray from top and fit the center rod from the bottom, so we emphasized this part in the user manual for refilling instructions. Also, since we decided to package the product in a fully assembled structure without the user needing to screw the central rod onto the top cap, we believe the confusion is minor.

Update in CAD:
For the screw at the bottom of the rod: we changed it to a piece of soft plastic notch that's connected to the bottom of the rod so it won't be lost easily when the user is disassembling the shaft to refill their products.
Standardize the screw size and hole size of the top cap: we changed the screw holes to 3mm to fit a standard M3 screw during assembly.
Poke-a-yoke techniques for caps: to prevent the users from mis-identifying the top/bottom caps, we decided to make top and bottom caps as slightly different diameters. Also, the bottom cap is made deeper than the top cap, so even if the user attempts to assemble the top cap to the bottom, the dimension would not fit.

2c. Design for Sustainability:

The sustainability of our product is shaped by its material choices, design process, and end-of-life disposal. The materials used in our product play a crucial role in determining its sustainability. A significant portion of the product is 3D printed using Polylactic Acid (PLA), a biodegradable material derived from renewable resources such as cornstarch and sugar cane. PLA is an environmentally friendly option because it is compostable under the right conditions and is less harmful compared to conventional plastics. However, the inner rod and bottles are made of standard plastic, which is less sustainable. While plastic production generally consumes less energy than metal production, it remains a significant contributor to pollution and waste. The handle of our product is made of latex rubber, which is not considered sustainable because its production relies on petroleum-based processes. Additionally, the metal screws used in the locking mechanism have the potential to be sustainable. Metal can be reused and last a long time, however it's nonrenewable and the mining of it contributes to pollution.

Our design process prioritized efficiency and minimizing material waste during production. Most of the prototype was 3D printed, which generally generates less waste compared to traditional manufacturing. But, the plastic used in the process (PLA) still requires considerable energy for production. Additionally, metal screws demand more energy and raw material, and their mining can be environmentally detrimental.

If well-maintained, the product could have a long life cycle. The 3D printed parts are durable but may deteriorate if exposed to extreme conditions. The plastic, rubber, and metal components all have relatively long life cycles, though they take a long time to decompose. Proper cleaning and maintenance by the user can extend the life of the product, allowing it to be functional for many years. However, improper maintenance or exposure to harsh conditions might reduce its lifespan.

Disposal is a critical factor in the product's sustainability. Most components of the product, including the PLA parts, are not easily recyclable through typical curbside programs. PLA is categorized as "other" plastic (type 7), which most recycling facilities do not accept. The plastic and rubber parts will not break down easily in landfills and may persist for decades. The metal screws, though recyclable, may not be sorted correctly during disposal and could end up in landfills as well. Since many components are not easily recyclable or biodegradable, the product is unlikely to be recycled properly by consumers. Therefore, the user can simply throw the product away without taking it apart. If consumers are environmentally conscious, they could potentially reuse or repurpose certain components, but this would depend on individual initiative.

According to the 2030 calculator, our current prototype has a 10.38 kg CO_2e carbon footprint. The biggest contributor was assembly at 7.32 kg CO_2e, followed by material acquisition and material processing. To improve the sustainability of our product we should use natural rubber, get locally sourced bottles, and use injection molding instead of 3D printing. Natural rubber produces a lower carbon footprint, is biodegradable, and can be recycled. Locally sourced bottles would reduce pollution from transportation. While the initial set up for injection molding is costly, it will use less energy to produce individual parts.

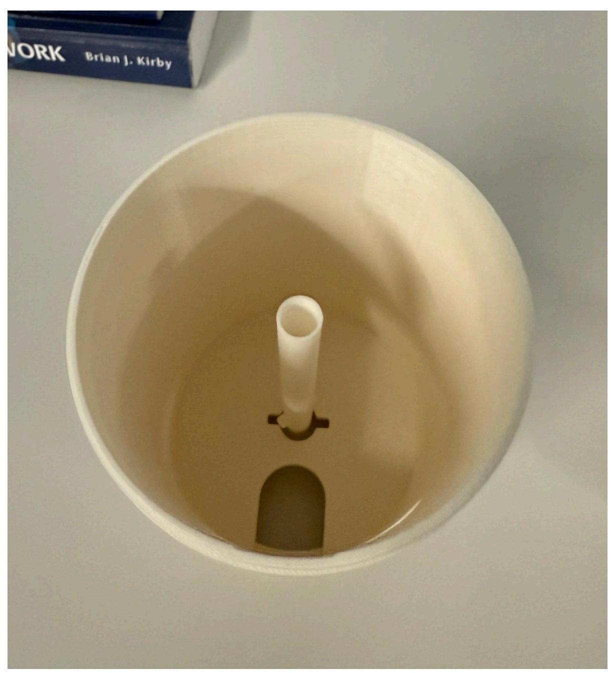
3. Final Documentation package → .zip file with…
   a. Complete budget and spending (BOM)
   b. Final CAD package
   c. Photos of prototype and the assembly process
   d. Any supporting documentation (I don't think we have this)
   e. All final prototyping files (STLs or STEP files, DXFs)

Bill of Materials:

Timeline	Part	Part Supplier (link)	Unit Price	Quantity	Cost
ODP3	Squeeze Bottles	Amazon, 3.4oz plastic bottles	$1.14	5	$5.69
ODP3	Outer Case	3D Printed	$130	1	$130
ODP3	Top Cap	3D Printed	$20	1	$20
ODP3	Top Cap Hook	3D Printed	$5	1	$5
ODP3	Bottom Cap	3D Printed	$20	1	$20
ODP3	Four-Bottle Holder	3D Printed	$20	1	$15
ODP3	Inner Rotatable Part	3D Printed		1	$10
ODP3	Central Rod	McMaster, lightweight plastic rod	$6/foot	1	$6.00
ODP3	Wire	Cornell	1	1	$1.00
ODP5	Top Cap	3D Printed	$20	1	$20
ODP5	Bottom Cap	3D Printed	$20	1	$20
ODP5	Outer Case	3D Printed	$130	1	$130
ODP5	Stretchy Band	Amazon	$2	1	$2

ODP5	Screw	Cornell	$0	2	$0
Total Cost					**$384.69**

Photos of prototype and the assembly process:

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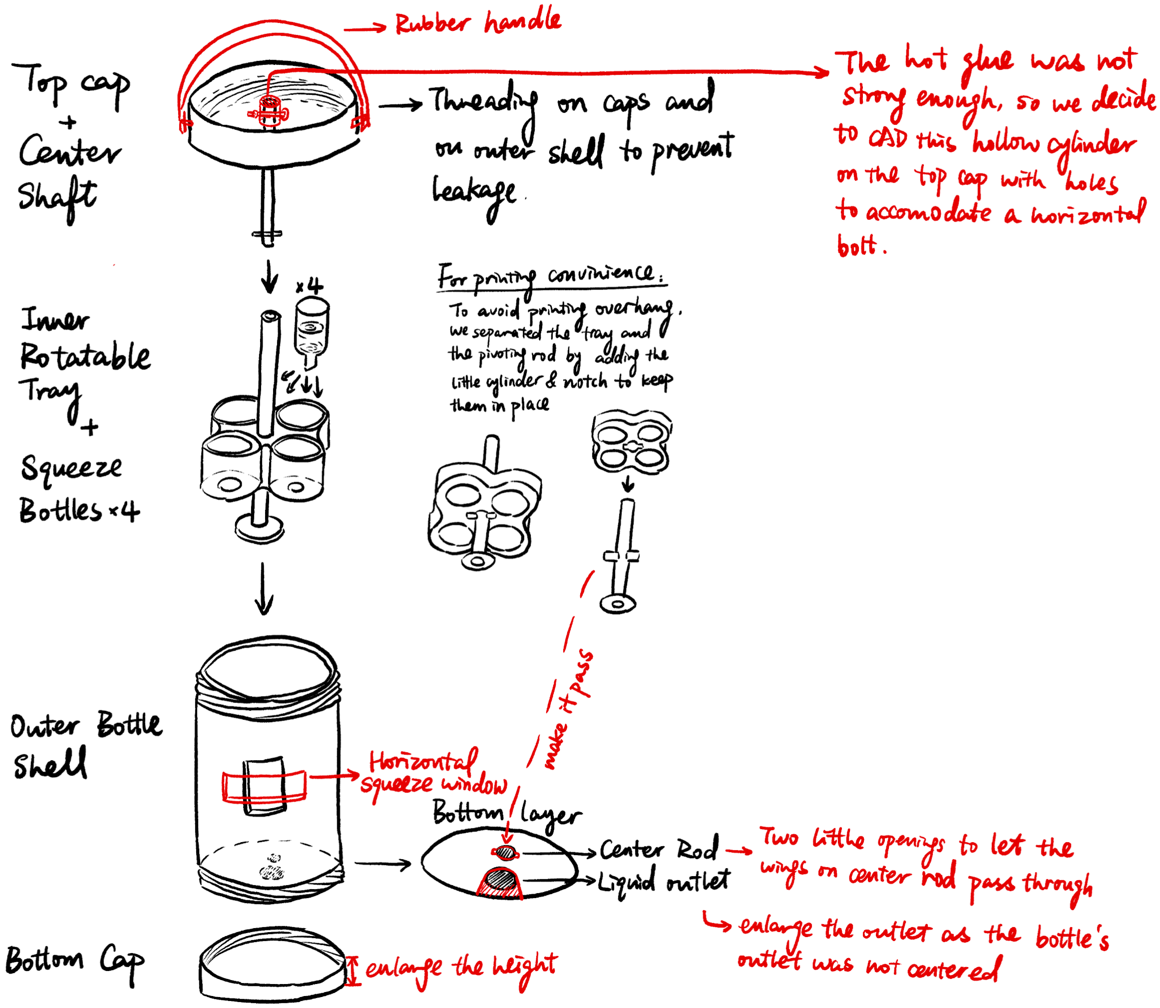
ROTATABLE COMPARTMENTED LIQUID DISPENSER

—Sketch



4. Final Recommendations:

We have decided to extend the development cycle of our product. We think that our product needs a few more iterations in the design process. We want to stick with our current market and target audience and gather more intel to ensure our product can thrive.

We believe that the product requires another iteration of the design cycle to reflect the DFMA changes previously laid out to see if these really improve the user experience. We also want to make the product waterproof by creating another custom part that would cover the cutout to rotate the bottles, which requires a redesign. In addition, the current functionality of the product requires more rigorous testing. This includes utilizing different types of fluids, testing the rubber band under different loading conditions, conducting water proof tests, assessing the performance of the product under different traveling conditions, etc. To truly understand if the product has potential, we believe we need to conduct more beta interviews to see if users find value and would buy the product compared to competitors.

Timeline over the next couple of months:

- Create the next prototype of the product implementing the DFMA changes outlined in Section 2 and proposed design changes.
- Conduct Beta interviews with users in the target audience and performance tests concurrently.
- Utilize feedback from interviews and testing to iterate once again or choose to enter the market.

5. Reflection:

Our team navigated the design process by following the steps laid out in the entire ODP process. Things that went well were that our team communicated well and had weekly meetings scheduled to work on the project together. If we needed to put in more time than our regularly scheduled meetings, we were able to find times to meet to make sure we were always on track. Things that didn't go as well were our 3D prints in general. We had issues with tolerances, especially for the threading of the top and bottom lids. Even when we reprinted these, the threading was still not as easy to screw on as we had hoped. We also had issues with getting the 3D prints on time. Since the majority of our model is 3D printed, our prototype assembly relied heavily on when the 3D prints were complete. For example, for ODP 5 (the final prototype), even though we sent our STL files to the RPL over a week before the due date, we were unsure if the parts would be printed before the deadline and actually had to go into the lab and talk to a worker personally asking them to skip the 24 hours after the bath that were needed for the parts to fully dry after the supports were dissolved. Thankfully, we were able to get the parts a few hours before the deadline.

The aspects of the design process that we enjoyed was brainstorming as it was fun to talk about wild ideas and then try to put things together into a solution. A few of our members also enjoyed CADing while others didn't like that part as much. Some members enjoyed doing the design tests as well. Overall, our least favorite part of the ODP process was doing the writeup and writing reflections, since it required self-reflection and self-criticism.

We learned a lot about project management working on this project. Our main takeaways were that it was much better for us to set up dedicated blocks of time where we would meet up and work on the project together. We weren't as good at doing work by ourselves but were very efficient when working together and making design decisions. We also learned that it is good to set action items for following meetings and to always keep the overall timeline of when things are due in mind. Talking through the timeline together ensured that we always completed assignments on time. As a team, we had a very fun dynamic where we got to know each other a bit in addition to just working on this project together. We didn't have any conflict, and we worked well under challenges and time pressure. We also delegated tasks to our strengths, which meant that things got done as efficiently as possible. Overall, Chips and Salsa was a great team to work with.