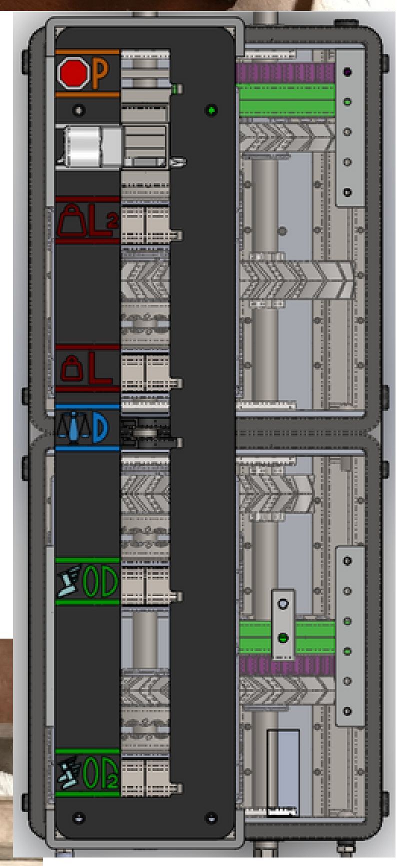
GEAR SHIFT TRANSMISSION — JUNE 2021 - MARCH 2023

From June 22 2021 to March 26 2023, I worked on a gearshift. This project really was the culmination of all my knowledge and experience, using everything I learned from the beginning of my journey. I extensively used variables and patterns - something I learned at the start of my time with SolidWorks. I defined almost all parts of the transmission within the main assembly, meaning if I change one component, all other components will conform to that change - something I learned to do with the Stirling engine project. I used the mini Sterlite crate from my Plastic Products projects, because the holes there provided precise places for the axles to go through in a nice, boxy frame. I extensively used gears to achieve different ratios - something I learned almost 6 months prior. I did extensive surface modeling to make the ergonomic gearshift knob and button - ensuring that there were no abrupt edges, and that all surfaces had a smooth C1 or C2 connection - something I learned in my long lofting and surface modeling journey. The clutches, which are the core of this project, included surface modeling, variables, and patterning to achieve the ideal geometric shape.

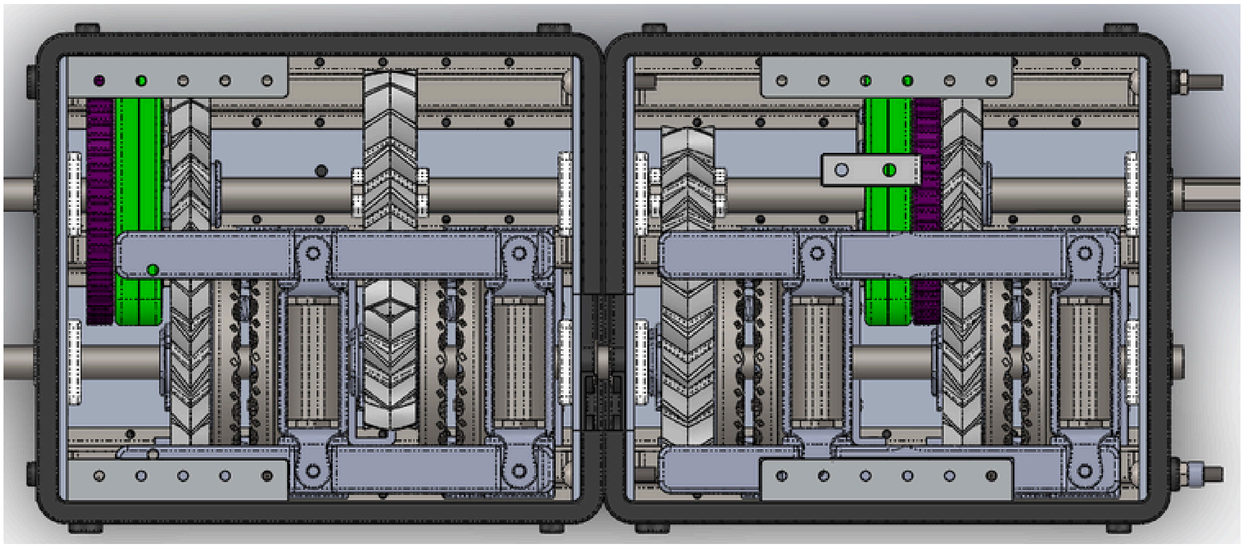
Below, I will go over each part and its workings in detail, and how I made them in SolidWorks.



G E A R S H I F T T R A N S M I S S I O N - H O W I T W O R K S

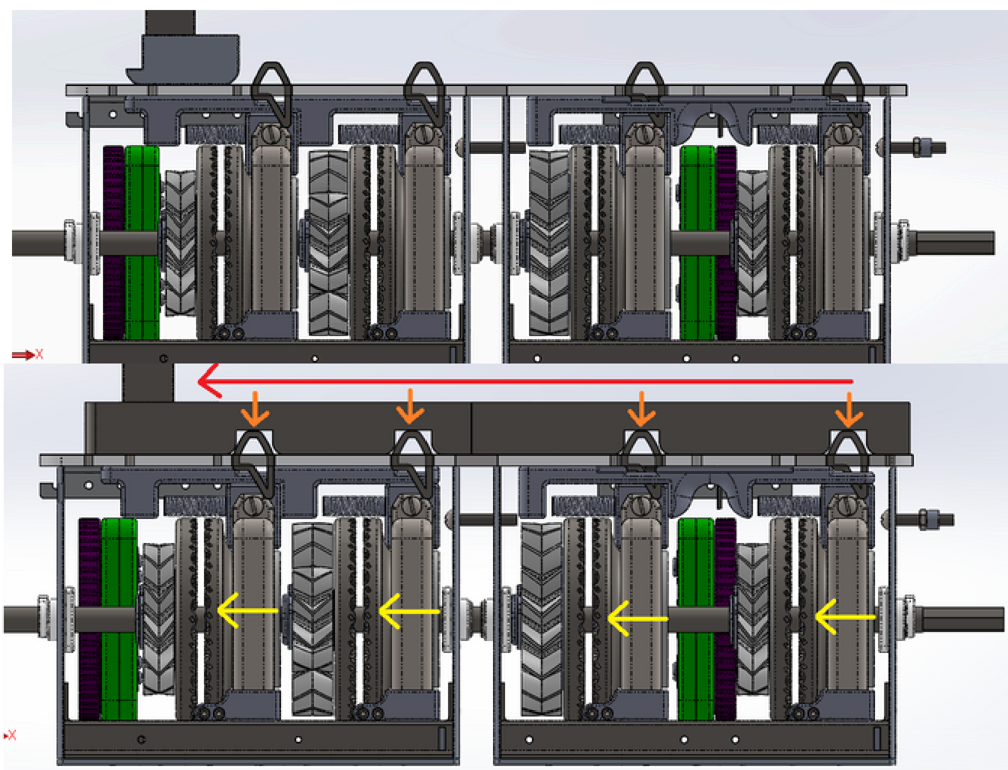
The transmission has two axles. One is an input axle (bottommost), and the other is the output (topmost). The output shaft has gears rigidly attached to it, meaning if the output shaft spins, then all the gears on it will spin as well. The input shaft has gears mounted onto it with needle roller bearings. This means that while the gears are on it, they are not rigidly attached, and so they can slip around the input axle.

On the input shaft are the clutches. Each clutch has two parts: One rigidly attached to the gears (recall that these gears can slip around the axle), and the other face that is locked with the axle. These clutch faces can slide axially, but rotate along with the axle (Later, I will show that there is a delay in rotation because of the shock absorbing springs). When moved forward, the clutches engage, locking each other. Because one clutch was locked with the rotation of the axle, and now both clutches are locked with each other, both clutches are locked with the axle, and spin as one unit. Because the clutch face connected to the gear is locked in with the axle, the gear no longer slips around the input axle, and spins along with it. Now that the engaged gear on the input shaft spins, it spins the gear on the output axle, and a ratio is achieved.



Each clutch is only allowed to move forward to lock in. This is achieved by using wedges, with angled bottoms. The face of the clutch that is allowed to move is housed in "carriers", which have an angled top. When the wedge moves down, it will force the carrier to move forward, engaging the clutch. The top of each wedge is shaped like a door latch. This is to allow the gear shift stick to slide smoothly over it. When the stick is slid over the wedge, it will force the wedge to move downwards. As long as the stick slides over the clutch, whether coming from the left or from the right, it will depress the wedge. Because all that is required for the clutch to engage is for the wedge to move down, it doesn't matter which direction you shift the stick.

Parking works by engaging all clutches at once. Because an axle can't spin at more than one speed at a time without shearing or deforming, by forcing all clutches to engage the gears, the gears will try to do this exact thing. This causes the entire gearbox to lock.



PATENT PENDING

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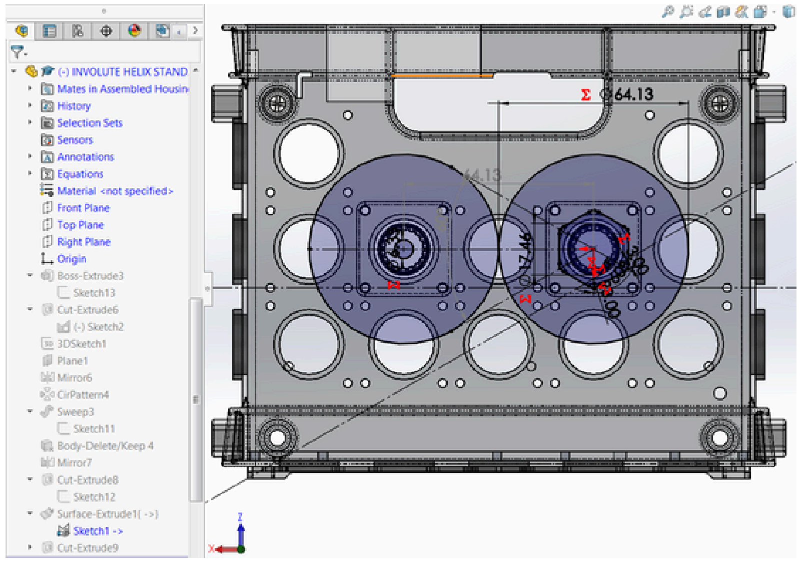
All gears are defined by five things: Pitch Diameter - the imaginary circles that roll on each other, teeth number, pressure angle - the angle at which teeth collide, and addendum and dedendum - how far the tooth extends past the pitch circle. (In most cases, Pitch Diameter and teeth number are grouped into Module). If those three inputs are defined, everything else gets defined: The base circle diameter, the tooth width and shape, and spacing.

For this project, because the distance between the holes of the crate weren't nice numbers, I decided to define the pitch diameters within the assembly itself. This way, the pitch circles of each gear would be centered on the axle hole, and their pitch circles would be tangent. I then fully defined the pitch circles by setting their diameters to be the distance between the centers multiplied by the ratio of teeth.

In the picture to the left, the ratio between the gears is 1:1. I used dimension between the distances (which was driven), and multiplied it by 12/12, because each gear had 12 teeth. For the other gears, I multiplied the distance by 18/9.

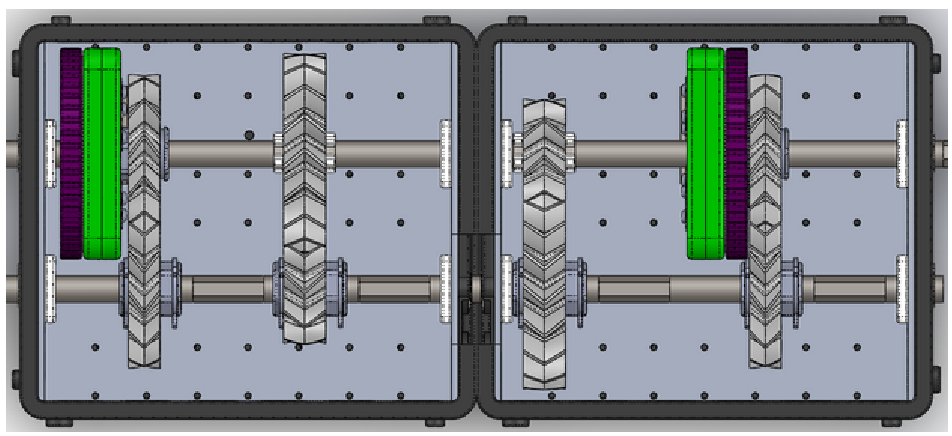


The ratios are as follows: (input : output)

1:3 , 1:2 , 2:1, 3:1

Sadly, I could not fit a direct drive with the space I had. (although I could fit parking).

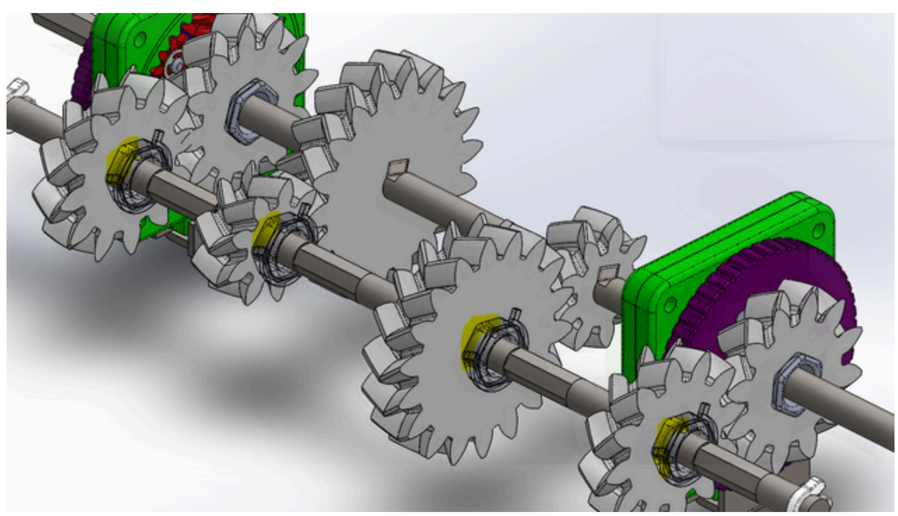
The 1:2 and 2:1 gear ratios are straight forward. The ratios are achieved with a simple gear pair. However, for any higher ratio, the small gear becomes so small, that it wither won't fit around the axle, or the axle bores too big a hole through it. This is why for the 1:3 and 3:1 ratios, I used planetary gears.



The 1:3 and 3:1 are achieved using planetary gearboxes, with the ring held.

In the 1:3 gearbox on the far left, the sun gear is the input gear, which then outputs the purple carrier. The carrier is then attached to the output axle. The sun gear is driven by the 1:1 ratio. Multiplying the ratios out - 1/1 * 1/3, the output is a 1:3 reduction.

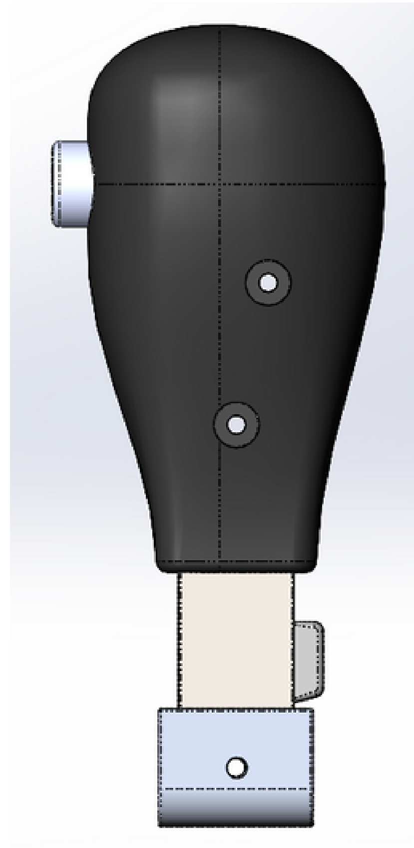
Similarly, the 3:1 gearbox is driven by a 1:1 gear ratio. The gray gears are then attached to the carrier, which then outputs the sun gear. The sun gear is connected to the output. Multiplying the ratios: 1/1 * 3/1, the output is a 3:1 overdrive.

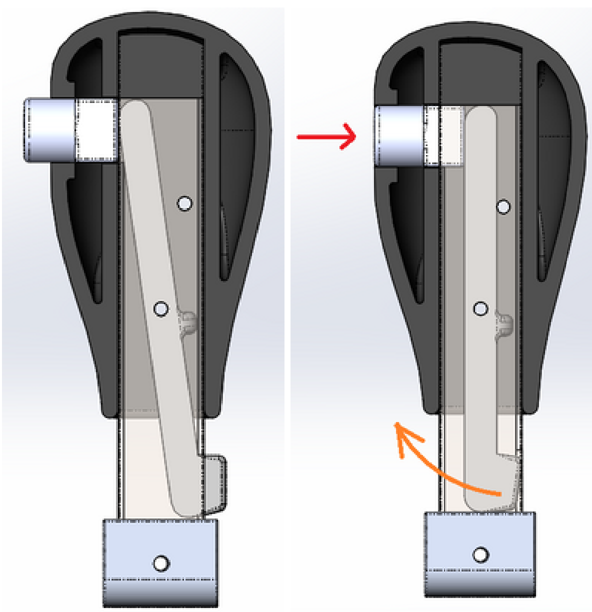


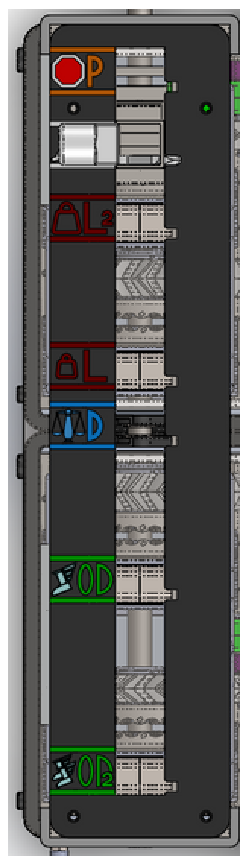
The gear shift knob is a very simple part. Because the gears are engaged by depressing the wedges, all that is required is that something presses them down. This is what the gear shift stick does. The bottom piece is called the "depresser". It has large arcs on its front and back to allow it to slide smoothly over the wedges, and has a large flat bottom to ensure that the wedge stays depressed. All that is required to shift to the correct gear is to ensure that the depresser slides over and stays over the correct wedge. This is what the latch is for.

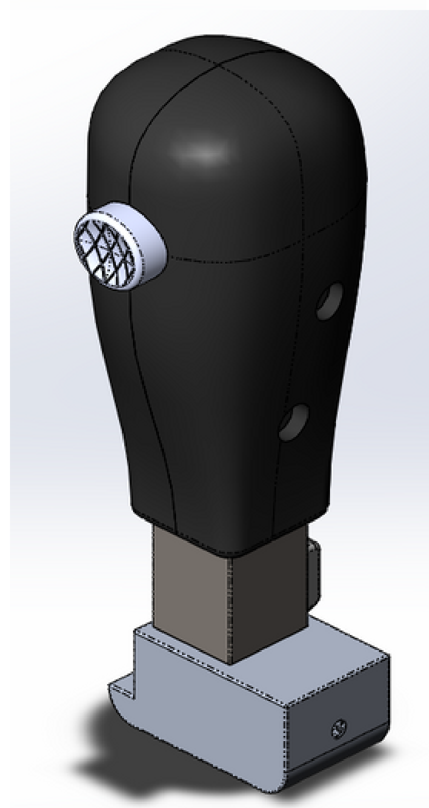
In the gear shift plate, there are notches on the right hand side of the large rectangular slot. These notches are positioned to their corresponding wedge. The gearshift stick is held in place over the correct wedge because of the latch and notch. This is all the gear shift stick does - slide and latch.

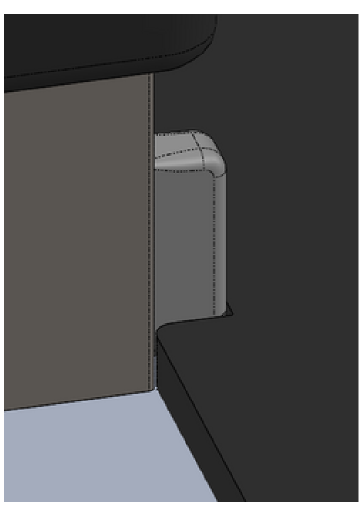
Because of this simplicity, the gear shift stick only has two moving parts: The latch, and the button. The latch is actually a larger piece, and is a lever. This lever is hinged on a screw, and tensioned by a torsion spring. When not pressed, the torsion sping will naturally rotate the lever so that the latch is out, thereby locking the stick into the notch. When the button is pressed, it pushes and rotates the lever so that the latch comes inward, allowing the stick to be moved again. The button doesn't need its own spring, because when not pressed, the lever, pushed by the torsion spring ensures that the button will be pushed out.











To achieve an ergonomic design for the gear shift knob, I used extensive surface modeling. I used many boundary surfaces and filled surfaces to achieve this, and I made sure that each surface was a C1 or C2 curve, and that there were no sharp edges on the model.

On the button, used another boundary feature to get the dimple. I wanted to make sure that the button was comfortable to press, and so I went with a surface that gently curved in towards the center.

To achieve the knurls, I used a linear pattern cut extrude.