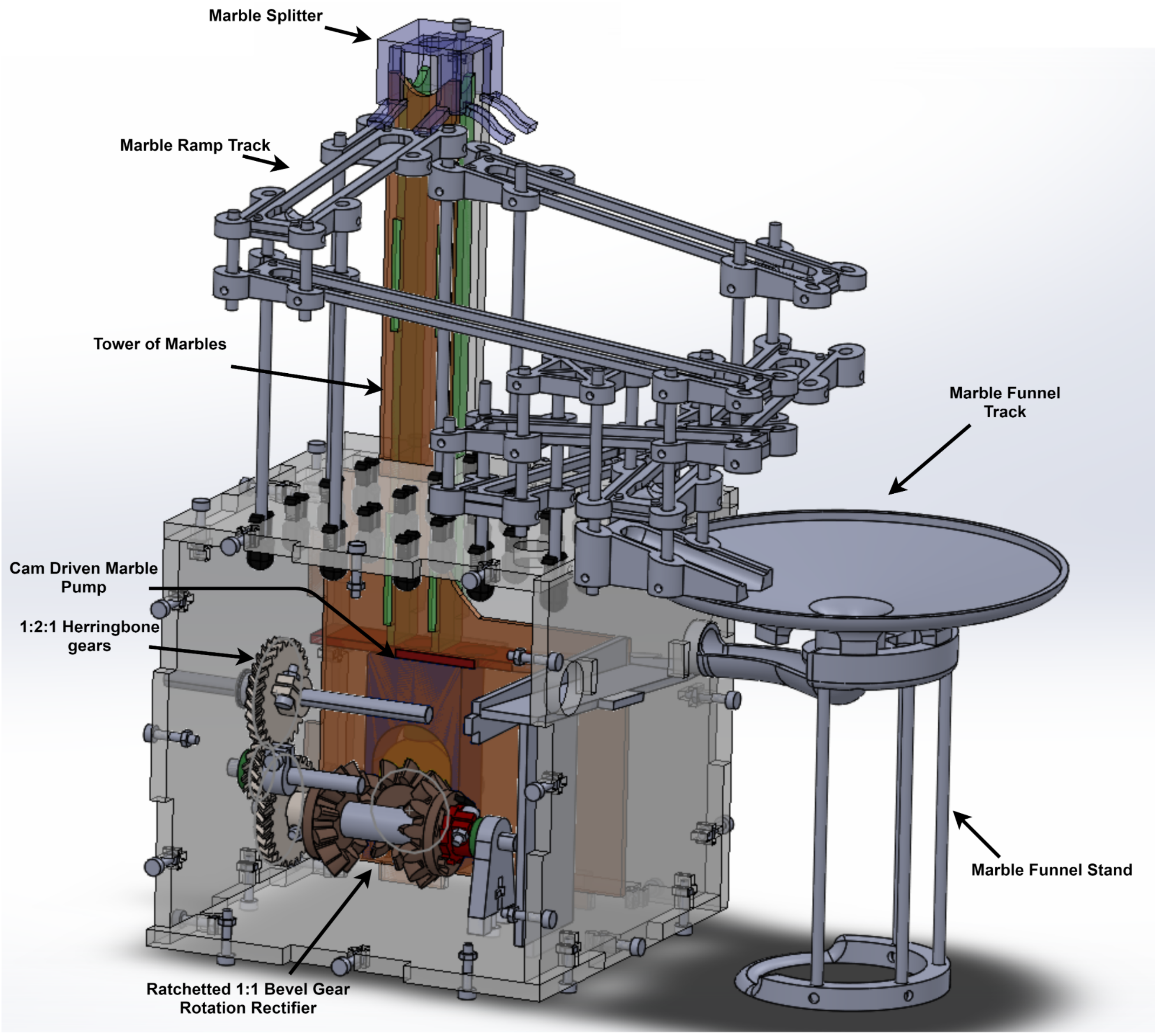
ECEN425 Gearbox

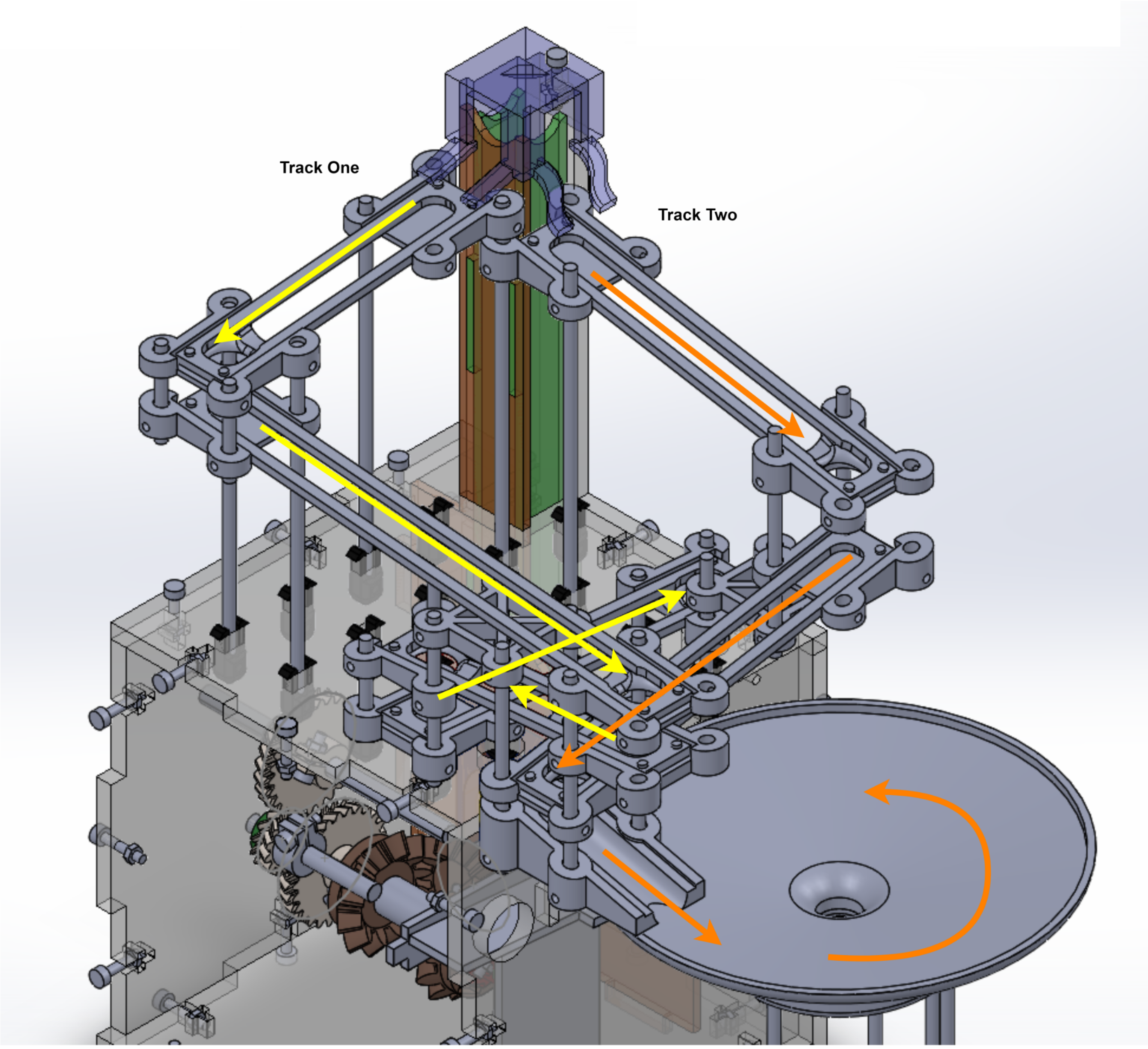
Joshua Benfell 300433229
Niels Clayton 300437590

Gearbox

Annotated overview of gearbox



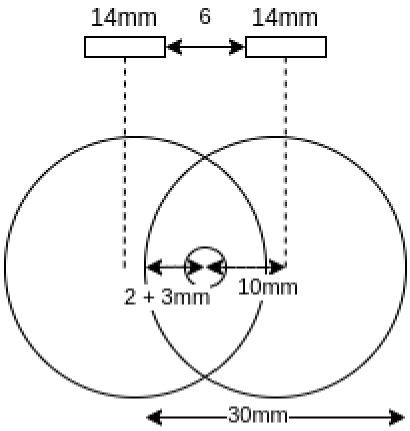
Annotated track paths:



Contributions

Joshua Benfell

The marble pump, herringbone gears and rotation rectifier
Niels and I sat down looking for ideas on moving marbles vertically and one of them was a marble pump that made use of a piston on a stiff wire (found here), to get marbles between two holes. We adapted this to use a circular cam instead of a bent bit of stiff wire.
To design this, we had to figure out the amount of horizontal movement we wanted, which would be informed by the distance between the two holes, 6mm, and would determine the final height of the mechanism. So it was calculated that the 6mm between the holes could be achieved with 10mm between the center of a 6mm shaft and the center of the cam when furthest to one side, for a 14mm hole, based on the 13mm average diameter of marbles. Combining this with a 24mm tall piston (as any smaller would result in the piston sticking out over the top of the moving block that went over the cam) gave us a total mechanism height of (10 + 15) x 2 + 24 = 74 mm block that was sliding horizontally.

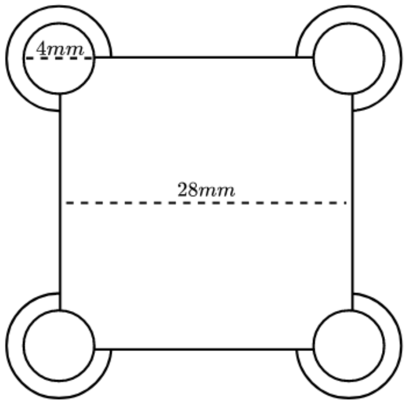


To enable the marble pump, we couldn't really rely on other gearboxes in the chain to rotate the correct way, as it was direction dependent, given that one direction would suck marbles out of the tower. So to rectify this, we used mechanical movement 49 from 507 movements. This involved making bevel gears that could fit a pawl in them, so ones from the toolbox were edited to allow this. From there, ratchets had to be made that would engage with these pawls. This was done by making a slice of a circle with a right angled triangle coming off the side and then creating a circular pattern to fill out the rest of the circle. There was no exact math to figure out how many teeth were required, it was just trialled until it worked. These then needed to be clamped to the shaft, and a spacer was put in between the free spinning gears to keep them the correct distance apart. Bearings were also put in these gears to aid the free spinning. Finally, another bevel gear was modified from the tool box to just have a clamp on it so it could drive the shaft that the cam was on, this was mounted perpendicular to the free spinning gears.

The input to the rectifying mechanism was not straight on the input shaft, so some gears were required to move the input shafts motion to a parallel shaft, driving the ratchetted gears. Some helical gears were made with the tool box, 2 of which had 26 teeth and another with 13 teeth. This was so that the gearbox had the required 1:2 gear ratio in it. The 26 toothed gears were both modified to have clamps, and the one that was on the shaft with the rotational rectifier had the ratchet joined to it so that it was one piece.

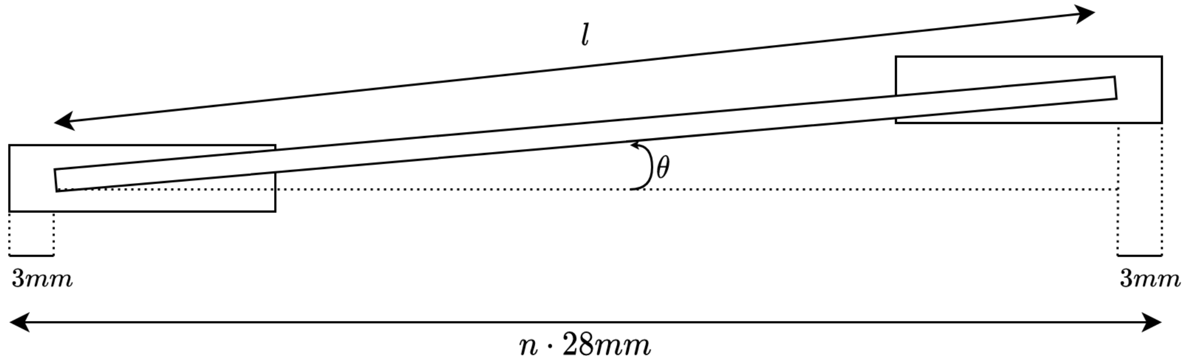
Niels Clayton

To facilitate the ability for new tracks to be designed and placed on top of our grea box, Josh and I decided that it was essential that we design a modular and expandable track system. To accommodate this, all track fixtures must feature the same footprint and mounting mechanisms as this will allow for any piece to be interchanged with another. This footprint came to be a 28mm square, with mounting holes located at each corner for a 4mm dowel rod to be threaded through as shown in the figure below.



With the footprint and the mounting method decided, a grid of dowel cups was generated and placed on top of the gearbox which can be seen in both annotated images. These cups are used to accurately space out the dowel rods used to mount the track components, and to provide support to the track. Each part of the track is made from three components, the starting ramp, and ending ramp, and the track. To provide more modularity and choice when designing a track for the gear box, all three of these components have been parameterised to automatically calculate and rebuild each part depending on the track angle requested, and the number of grid spacings traversed. In the figure below we see the calculation for the length of a track of a specified angleθ, and spacing n. Within solidworks all three of these parts have variables that can be specified, allowing for the generation of any angle and length of track that will fit our modular system easily.

There were spacer components designed to this same footprint. These spacers allow for the track to extend past the dowel cups on the roof of the gearbox, providing the same spacing and support.



$$l = \frac{((n \cdot 28mm) - 6mm)}{\cos(\theta)}$$

Explanation of the Gearbox

Gearbox

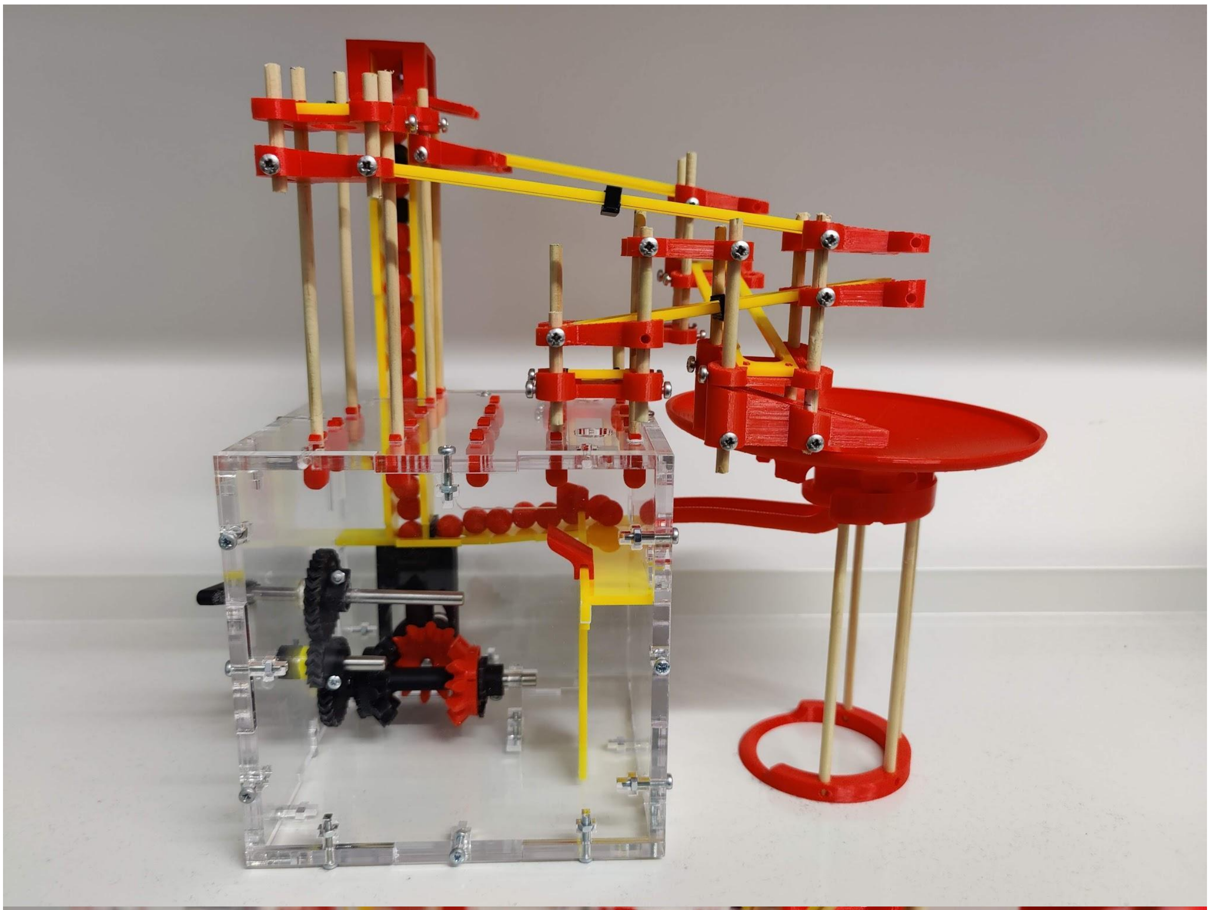
From the input shaft, herringbone gears are arranged in a 1:2:1 ratio, transfering the motion of the input shaft to a parallel shaft. The shaft that is driven by the helical gears has two ratchets attached to it, facing opposite directions. These ratchets each engage with a bevel gear that is not locked to the shaft, but free spinning. Regardless of the input rotation direction, only one of the ratchets will engage with a bevel gear. This will drive the gears in the same direction regardless of the shaft's rotation, in turn driving the third output bevel gear in only a clockwise direction. This is required as the next section is a marble pump which makes use of a cam follower to move marbles under a wall and up a tower. If this was to rotate in a counter-clockwise direction, then it would instead move marbles out of the tower. As marbles are pumped up the tower, those at the top fall out into one of two paths, down a series of slopes or down a funnel. Finally there are a series of ramps inside the box to catch the marbles and queue them up for the marble pump

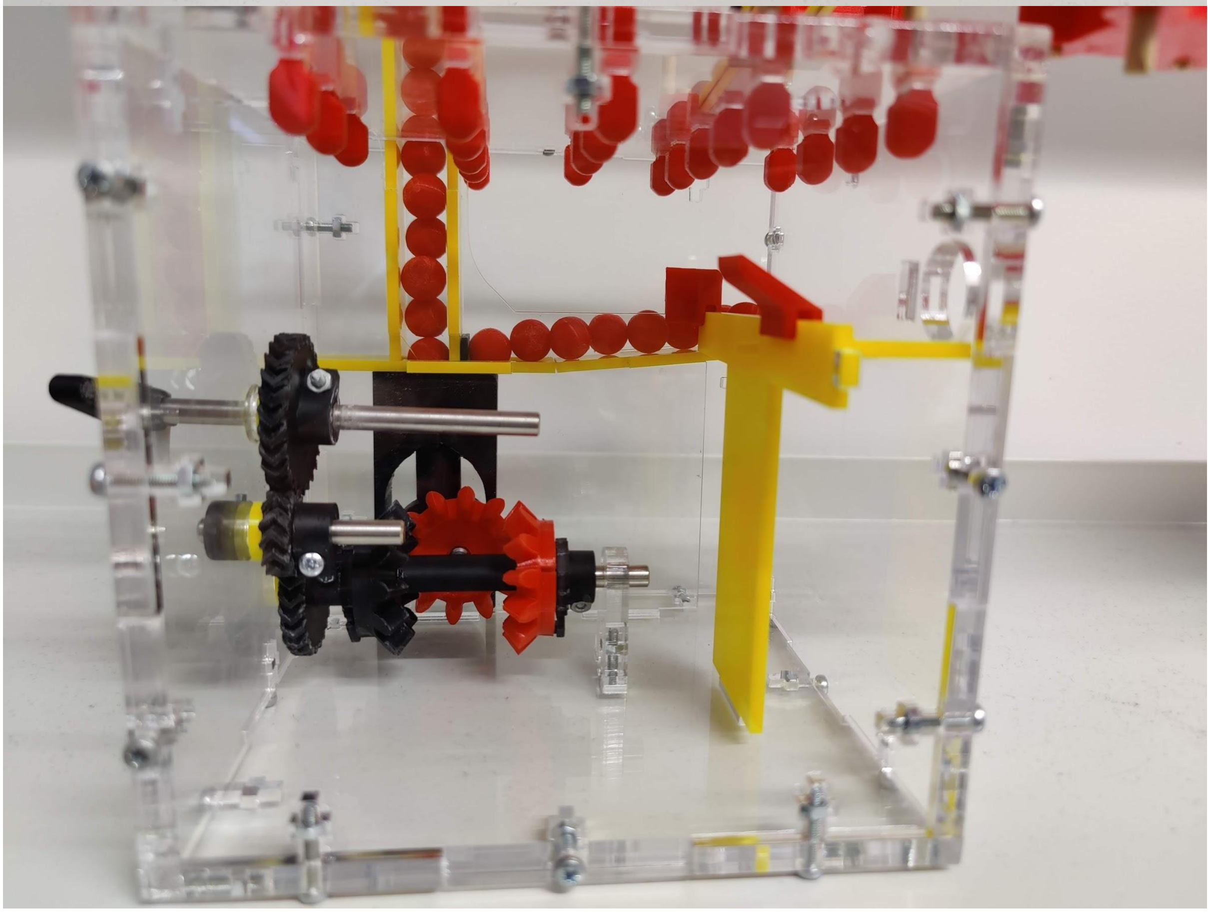
Track

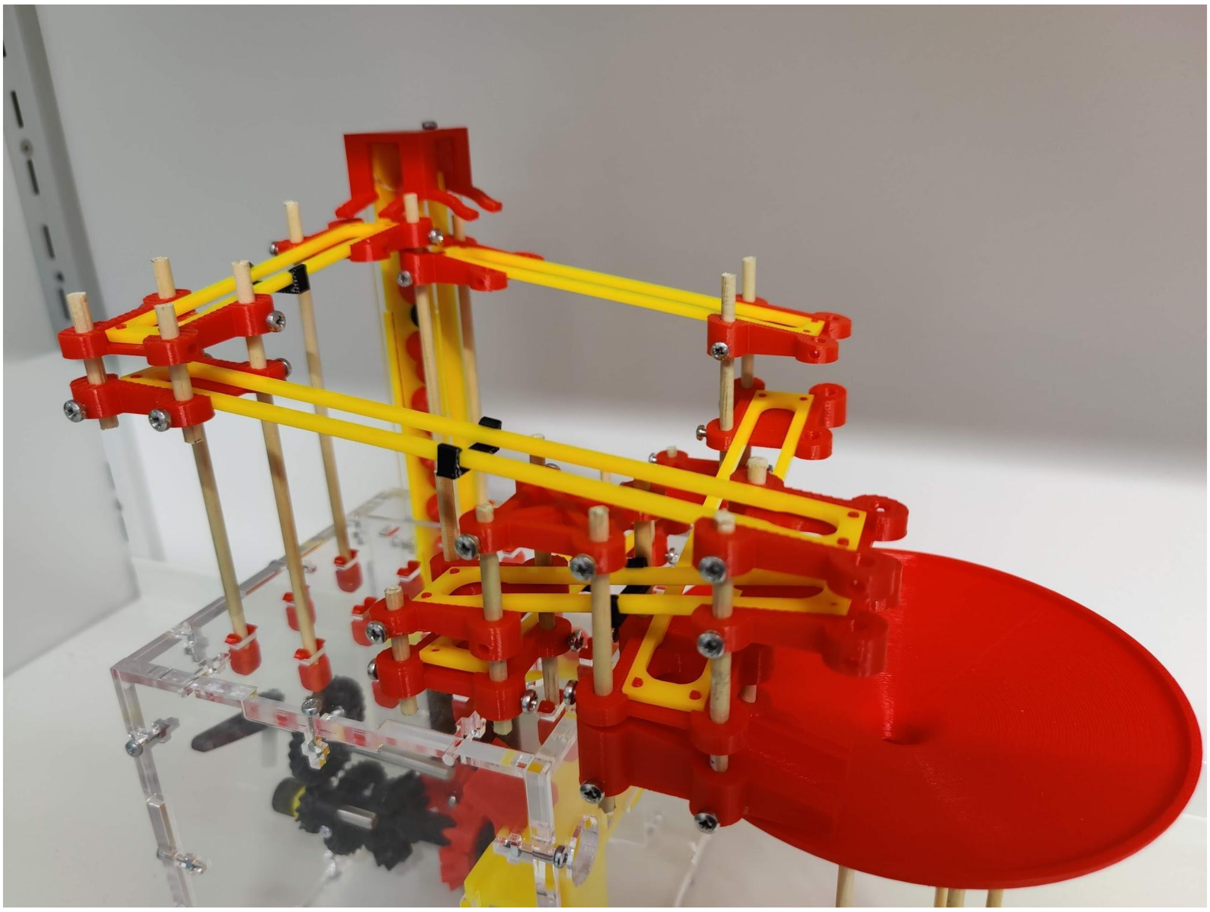
The track mounted on top of the gearbox has been designed to be completely modular such that new track layouts can be designed and placed on the gear box. On the top of the box is a grid of dowel cups separated by 28mm gaps in all directions. These dowel cups allow for the accurate placement of dowel supports on top of the box, providing the supports for the designed tracks. These tracks are made up of track start ramps, stop ramps, and spacers, all designed to fit on this 28mm grid. These track start and stop ramps come in a variety of track angles and lengths to allow you to design and implement your own course on top of the gearbox.

In the case of our gearbox there have been two tracks designed. The first consists of a selection of straight linear rails of varying lengths, depositing the marble into a hole located on the top of the box, denoted as track one in the annotated track paths image. The second track delivers the marble to a conical funnel at which point the marble will spiral into the funnel and enter the gearbox again through a side mounted tube.

Finished Gearbox Images







Fabrication Material Requirements

Laser Cutting

To make all the laser cut parts, you will need at least:

- A 305 x 275 x 3 mm acrylic sheet
- A 315 x 525 x 6 mm acrylic sheet

These will be used to make the 3mm and 6mm laser cut parts for the gear box.

3D Printing

To 3D print all the parts for the marble machine, you will need approximately 303g of filament

Wooden Dowel

You will need approximately 1.5m of 4mm diameter dowel to support the marble track design supplied. This dowel can then be cut into all the required lengths listed in our bill of materials.