HARRISON ROBOTICS

FRC 4521

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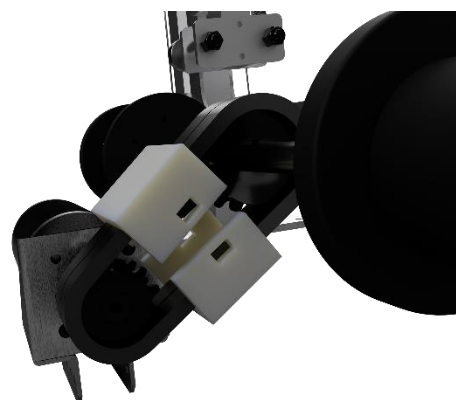
Elevator

The elevator is the central mechanism of the robot. It moves the arm which moves the grabber. The design is a two-stage cascade elevator actuated by cables that are driven by two pulleys.

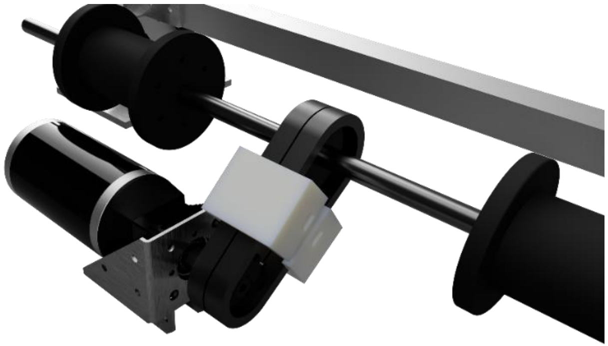
To guide the linear motion, we designed custom linear bearings with integrated pulleys. The motion-guiding portion uses standard ball bearings on 3/8” button-head bolts. For the pulley portion, we used a lathe to notch nylon round-stock, which is on top of a needle bearing, which rides on oilite bronze bearings. All of this is held together by the 3/8” bolts and custom laser-cut aluminum parts.

The linear motion guides are mounted to the frame at all four corners with rivets. We fabricated the frames from aluminum box extrusions, held together by custom laser-cut brackets.



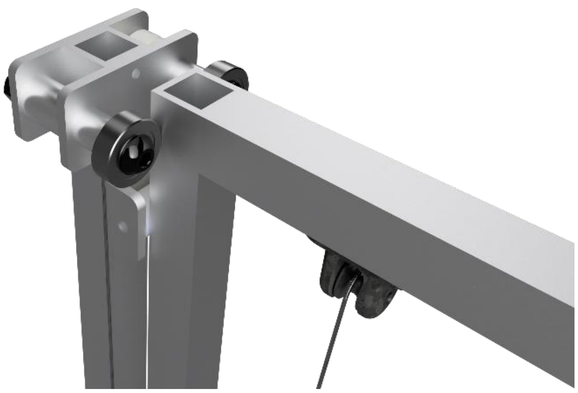
The chain transmission with tensioner

The cables that actuate the elevator are driven by a transmission at the bottom of the frame. The transmission transfers torque from a motor to a 10:1 planetary gear box to a sprocket-chain system to a shaft with spools upon which the cables are wrapped. The chain in the transmission is tightened by a custom tensioner. We designed it to use UHMW C-channel extrusions (ideal for the chain to slide on) which are pulled together by zip ties, which can be changed quickly.

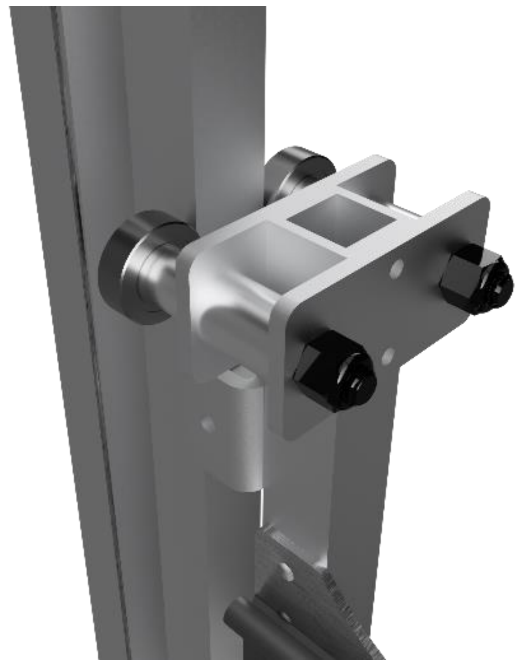


Up close of the entire transmission

An exploded view of a linear guide



This is the top of the elevator, where the linear guide can be seen



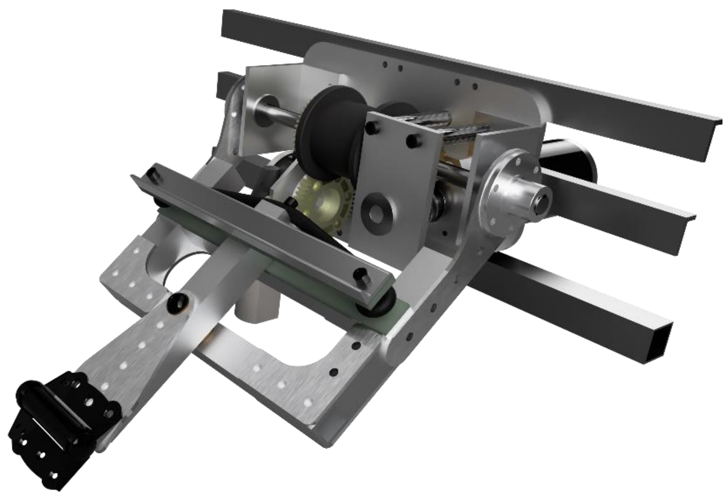
A linear guide riding on the intermediate frame

Side view of the elevator

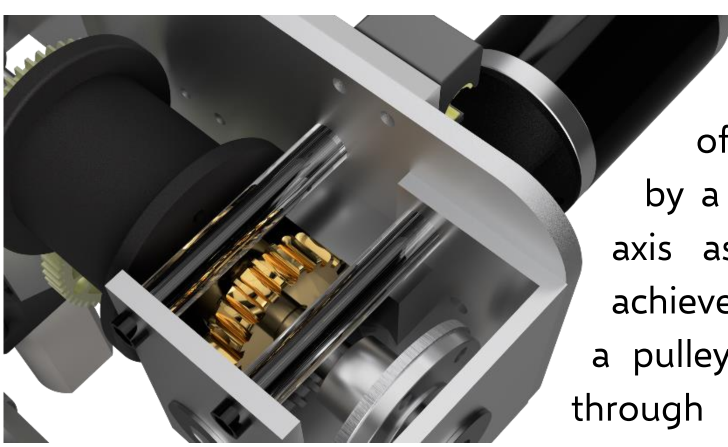
An assembled linear guide

Arm

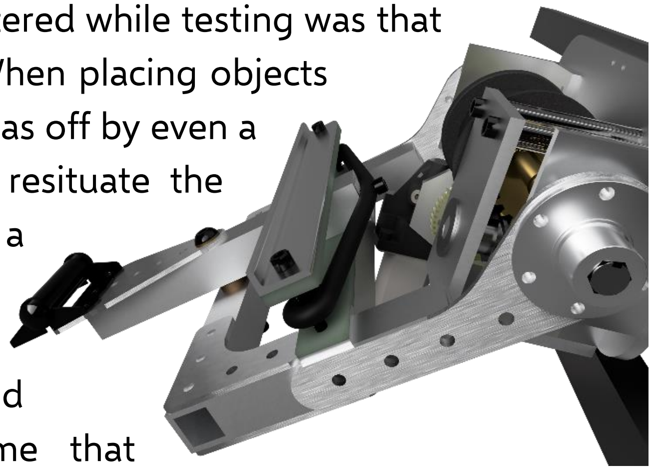
The arm is the smallest of the main components; however, the arm allows the robot to reach a few feet higher than it could without it—which makes all the difference. The grabber we designed is quite large, so the arm must be powerful and sturdy. The entire arm is mounted on a laser-cut aluminum plate, so the part can be easily taken off the elevator.



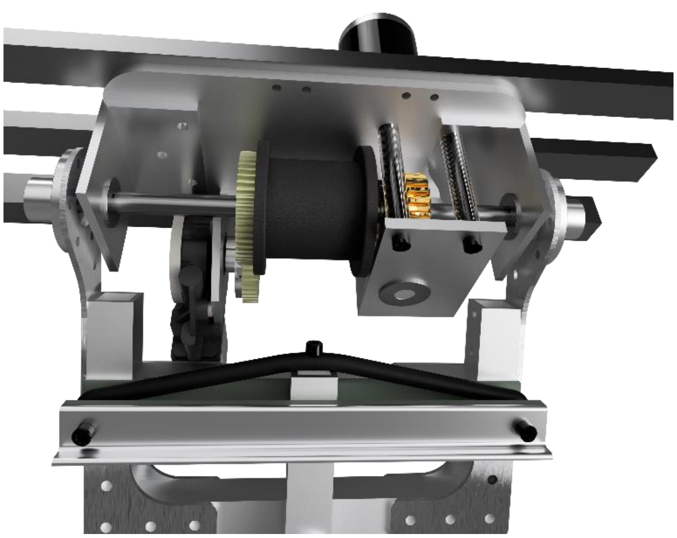
The arm has two areas of movement: the elbow and the wrist. The elbow is powered by a large motor which drives a 38:1 planetary gearbox. This box drives a custom 90˚ gearbox that we designed. Our gearbox's input is a steel worm gear which drives a brass spur gear at an 8:1 reduction. The gearbox's housing is made up of machined aluminum angle-stock bolted to a 1.5" machined aluminum bearing block on the bottom and supported by ¼-20 bolts with polycarbonate spacers on the top. The brass gear is pinned to a high-carbon steel keyed-shaft. The shaft drives aluminum hubs on either side of the plate mounts. The hubs are then connected to the arm frame by water-jetted brackets.

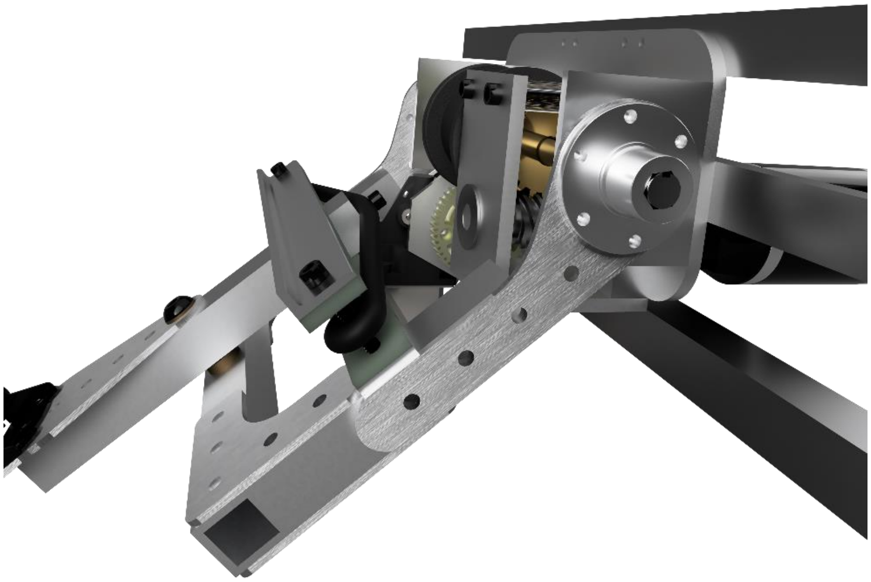


The wrist pivots on a spring-loaded hinge at the end of the arm. The wrist is powered by a system that runs on the same axis as the keyed shaft. This was achieved by pressing ball bearings into a pulley drum and running the shaft through the bearings. This allows the drum to run independently of the shaft while being around it. Mounted to the side of the drum is an aluminum spur gear with no center, to allow the shaft to pass through. This gear is driven at a 1:1 ratio with another gear which is mounted to a small snowblower motor. The aforementioned pulley drum pulled/released a cable that attached to the top of the grabber.

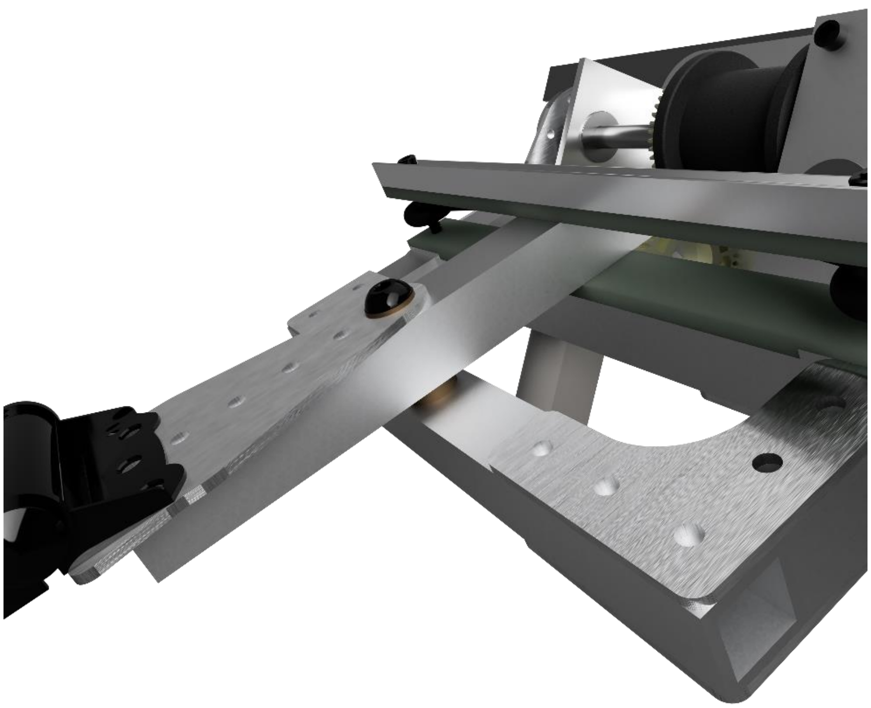


One problem that we encountered while testing was that the arm, was that it was too stiff. When placing objects with the grabber, if our alignment was off by even a small amount, we would have to resituate the robot. To fix this, we designed a system on the arm frame to allow just the right amount of give. The main part of the frame is a rigid rectangle. The part of the frame that connects to the grabber (via the spring-loaded hinge) is a separate front extrusion. The two components are attached by a single 3/8" bolt that rests on bronze oilite bushings to allow free rotation in the horizontal plane. To limit this horizontal motion as well as eliminate vertical motion, we designed a linear race on the back of the arm frame. The race is made of two oil-impregnated cast nylon bars sandwiching the back of the front extrusion. The nylon bars are backed on either side by aluminum extrusions. The top backing is held by two bolts that can be retensioned to change the amount of motion allowed. Finally, to keep the front extrusion near-center when not being pushed, we used silicone surgical tubing to exert tension on the extrusion from both sides.





A side view of the arm

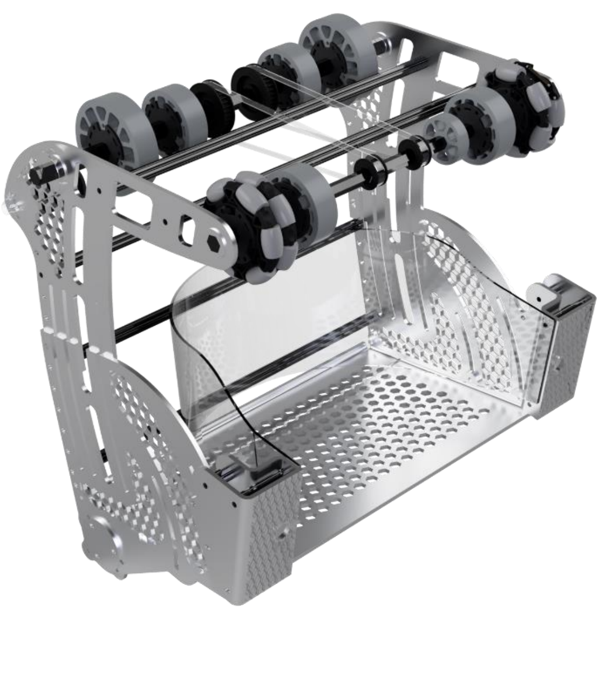


This view shows the point where the two parts of the frame meet at a bolt as well as the linear race which can be seen in the back (the green parts are the nylon bars)

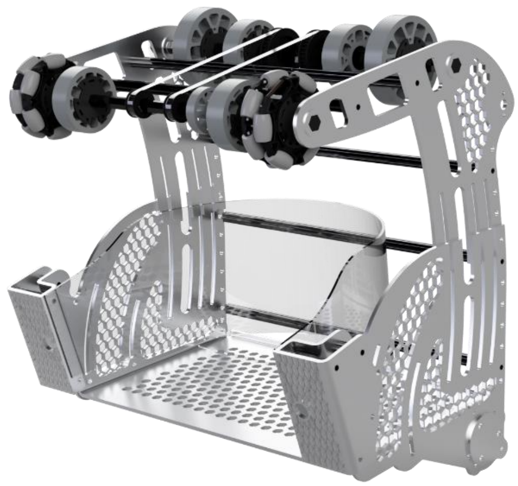
Grabber

The grabber is the part of the robot that allows us to pickup/place the ball and disk game pieces. The grabber needed to be large to hold the large pieces. The grabber's frame is made of laser-cut aluminum sheets, bolted together. We designed a hexagon relief pattern into the patterns to cut down on weight.

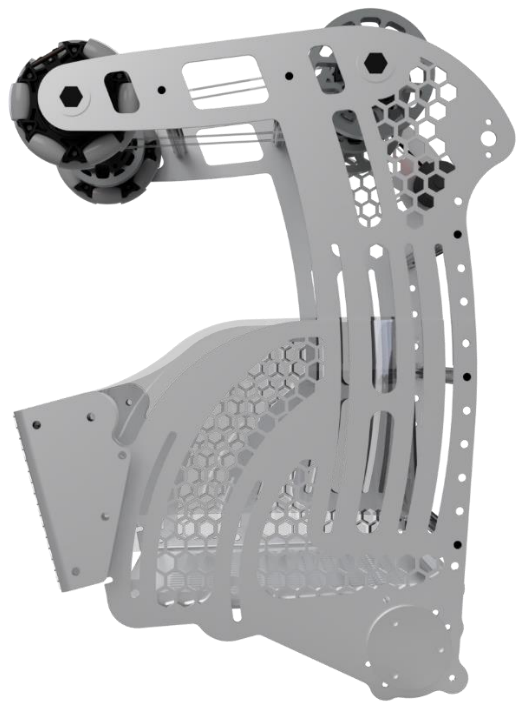
The ball is held in the center of the grabber. Two rows of wheels at the top of the part pull the ball in and eject it when needed. The outside wheels are omnidirectional; this means that if the ball is slightly off to the side, the wheels will allow it to be pulled to the center. The center wheels are made of compliant, sticky silicone and arranged to conform to the ball's shape. The rear row is driven by a urethane belt that is driven by a motor. To interface the belt with the motor, we machined an aluminum fitting and press-fit it to the shaft. The rear row of wheels also drives the front row via more urethane belts, which also assist with ball handling. The pulleys used with the front are 3D printed.



To handle the disk, we use Velcro and pneumatic cylinders. The disk is picked up from the ground or the wall by pressing the grabber's Velcro against it. When the disk is ready to be released, the pneumatic cylinders push it off the Velcro from behind.



Front view of the grabber with the polycarbonate back guard visible



Side view of the grabber; the cuts on the side allow the grabber's height to be fine tuned