VEX ROBOTICS

Makers Mill

Making It More Real

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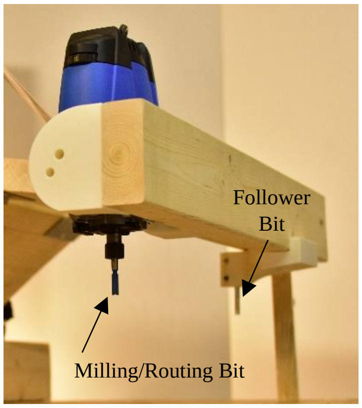
Make It Real CAD Engineering Challenge Sponsored by Autodesk

Introduction

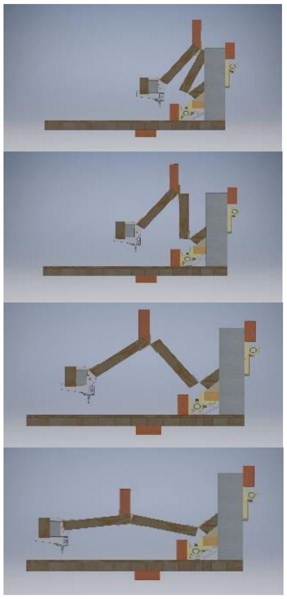
Over the past decade, 3D printing has gone from being an exclusive system – limited by patents, prices, and steep learning curves – to being a tool for making and learning – accessible to students, hobbyist, and professional – and quickly advancing due to support from open-source designs, huge online communities, and access to powerful computer aided design (CAD) software such as Autodesk® Inventor™, Autodesk® Fusion 360™, and Tinkercad™. Nevertheless, 3D printing, specifically fused deposition modeling (FDM) printing, has some drawbacks that this project hopes to address. The Makers Mill is a multipiece design that allows makers to trace 3D printed designs, carving them into other materials, including plastics, wood, rubber, foam, and even soft metals.

How does it work?

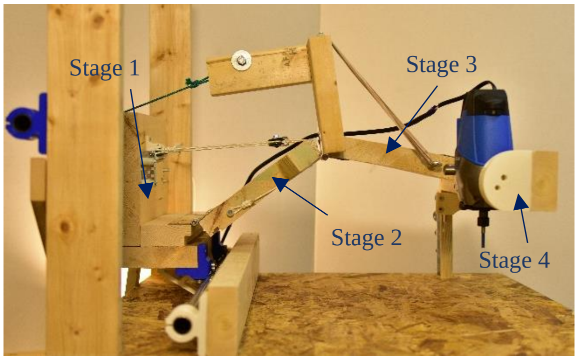


The goal of this project was to create a component set that would integrate into the workflow of one of the most common static desktop "robots" – the 3D printer. Users start by creating their design in CAD (Autodesk suite highly recommended), and then 3D printing it. This print is then secured to the Makers Mill alongside the piece of material that the design is to be carved into. An appropriate milling or routing bit is installed in the router, and the matching follower bit is also clamped in place. From there, the model is traced with the follower and thus carved into the other piece of material.

Mechanics



The design consists of four stages corresponding to four degrees of freedom while keeping the cutting and following bit parallel at any given position. Horizontal translation is achieved using the first sliding stage, depth and vertical movement use the bi-folding second and third stage, and one axis of rotation is obtained from the hinging of the fourth stage. The particular combination of rotating and sliding joints was selected specifically to minimize the table space required when not in operation. This was important because many workshops and classrooms lack the real estate to dedicate the required space to a single tool.

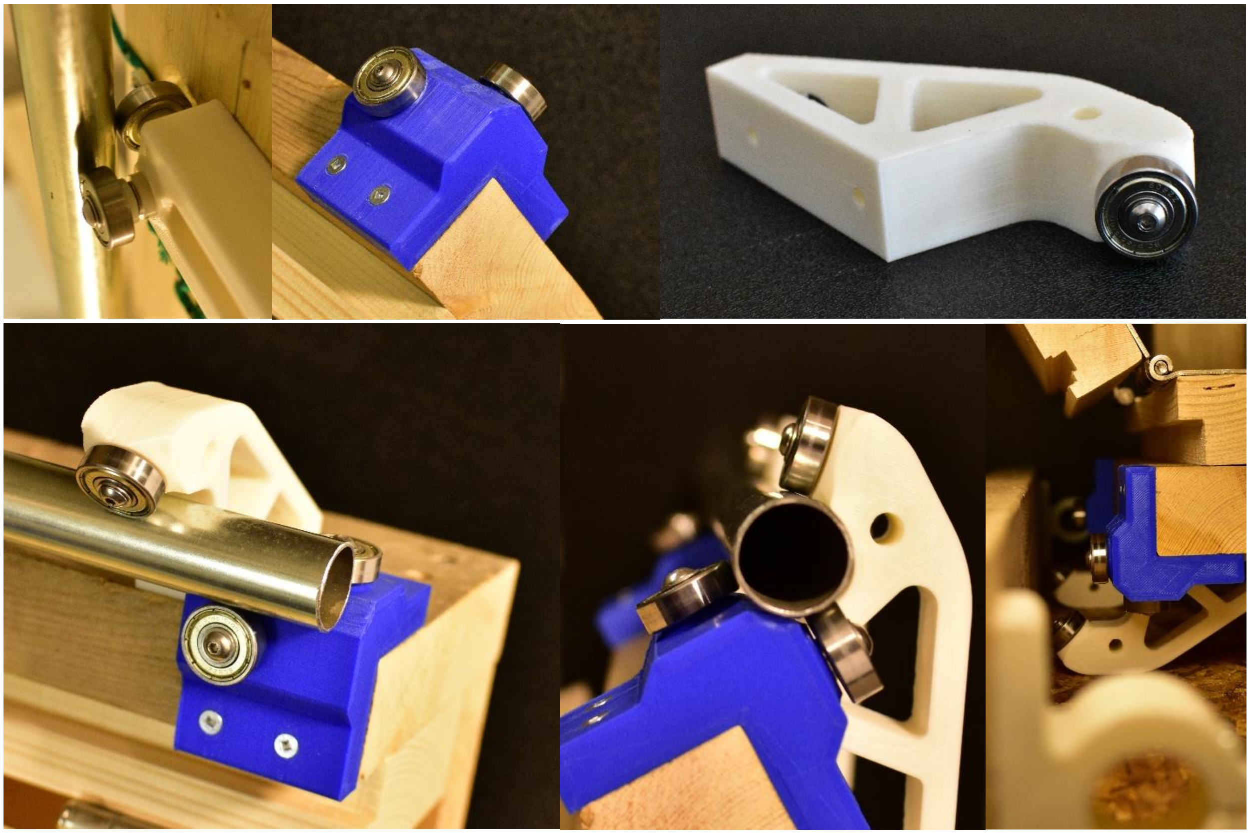


Subcomponents

The following subcomponents were custom designed, and 3D printed for this application, but would also be very useful in other robot mechanisms.

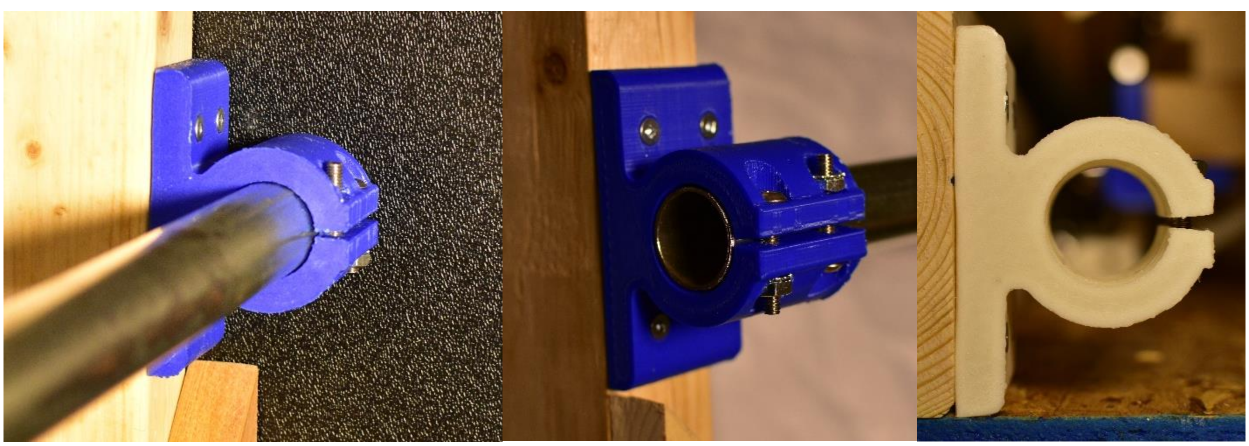
Linear Slide Bearing

Three mounting brackets were designed to secure the first stage to two cylindrical sliding rails:



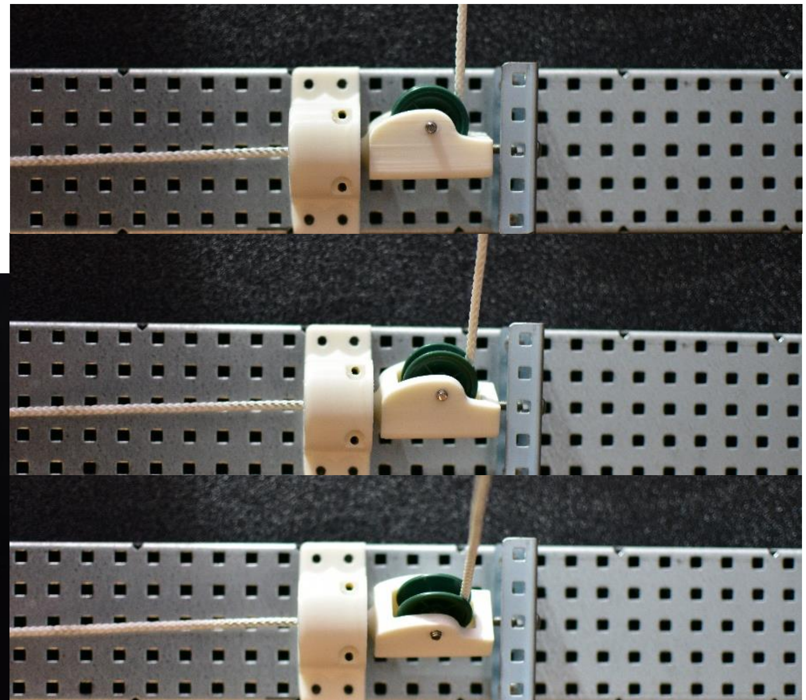
Slide Rail Mount

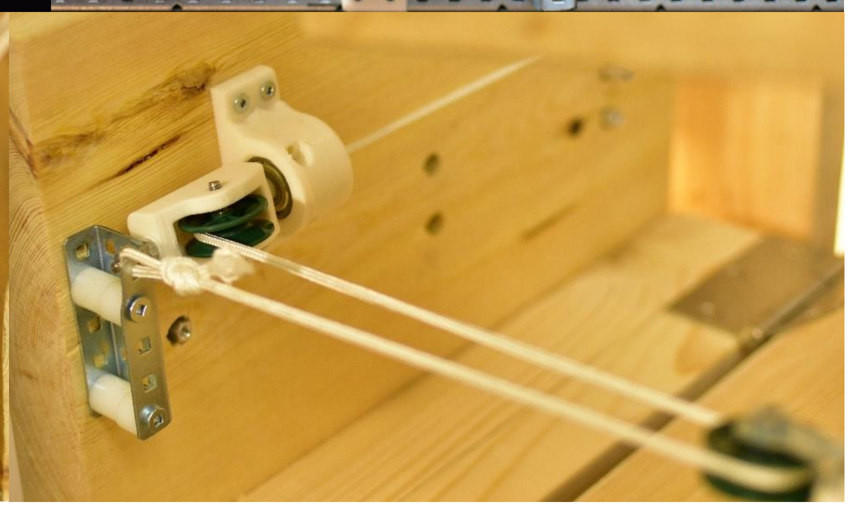
The rails (1” steel tubes) were secured using a mounting bracket on each end.



String Passthrough Hinge

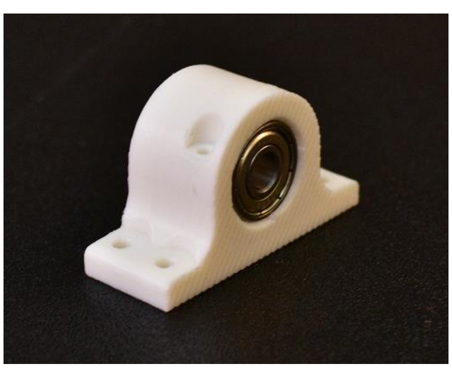
Rope tension through this piece is independent of the angle of the joint. This attaches a counterweight to the second stage which doesn't need to slide with the first stage.





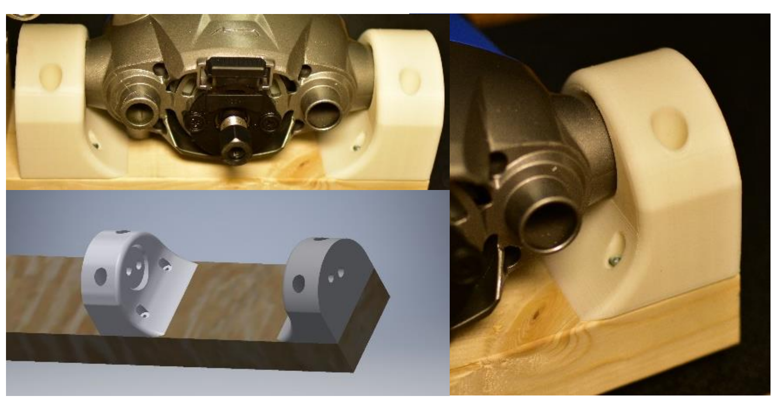
Ball Bearing Mount

Bearing mounts are designed to handle radial and axial loading.



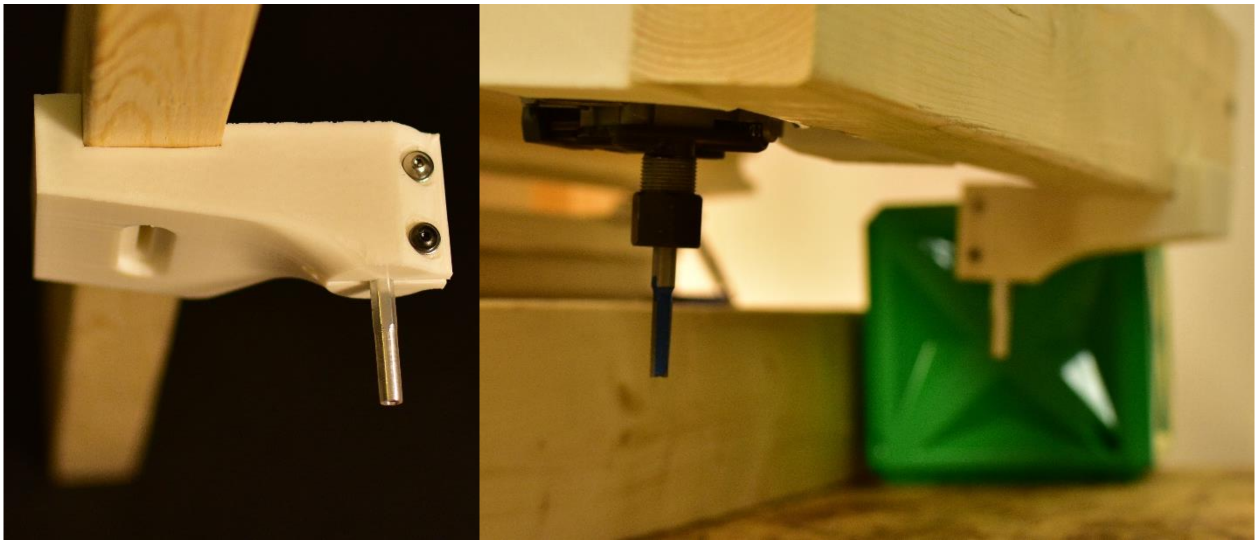
Router Mount

Custom mounts secure the router to the 4th stage.



Follower Bit Mount

Follower can be clamped in at any height while remaining parallel to the cutting bit.



Applications

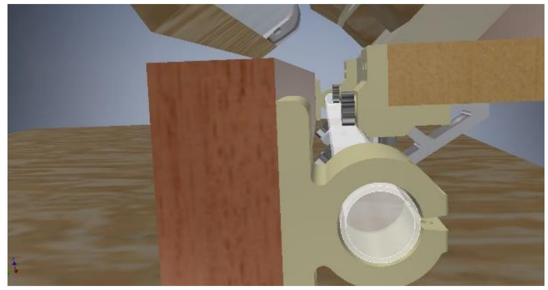
This project pertains specifically to the VEX Robotics Competition as 3D printed parts are not permitted in the high school division. That said, the past years of the *Make it Real CAD Challenge* show that students are eager to use this technology to customize parts for their robots. The Makers Mill motivates students to learn these CAD skills by enabling their designs to be carved into competition legal components (ie: gears, standoffs, Lexan).

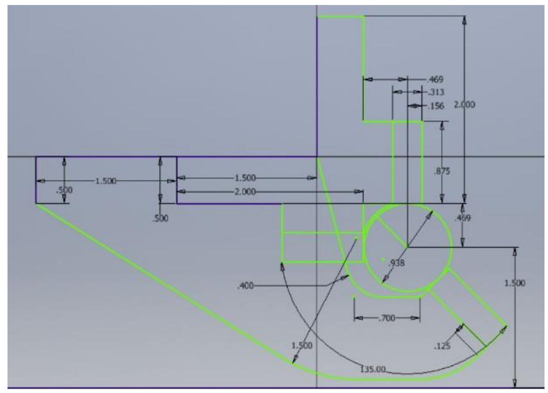
While promoting creativity, the Makers Mill also has significant potential in improving the sustainability of 3D printing. By melting down failed prints and support material into solid blocks of plastic, otherwise wasted material can be recycled and then carved into working components or models with potentially stronger structural properties.

Lastly, the wide variety of compatible materials opens many opportunities in STEM and artistic fields. Some ideas include:

- Rubber stamp making
- Foam aircraft modelling
- Wood Carving
- Stencil making
- Personalized engraving
- Lithophane duplication
- Ice or food carving
- Material testing samples

Design Process





Because previous projects made use of the Fusion 360™ and Tinkercad™ software packages, this project utilized the 2019 Autodesk® Inventor™ software package in order to expand the depth of our experience. Because the developed component kit had to integrate with other standard products, namely wood, screws, ball bearings, and hinges, it was important to plan out the geometry before purchasing or cutting out the various pieces. Each subcomponent was modelled and then put together using Inventor's™ assembly constraints. As the design progressed and was further refined, individual parts could be adjusted while others could be reused and remixed for other functions. As a mentor, simplifying the otherwise time-consuming geometric configuration allowed me to focus on exposing the students to more advanced engineering concepts such as stress concentrations and manufacturing tolerances.

Conclusion

Through this project, I learned one of many ways in which the Autodesk® Inventor™ package can be integrated in the creation of new component sets, particularly around other standard materials. In continuing this project as well as many more projects to come, 3D design software will definitely play a key role. On a competitive robotics team, this type of digital design is very useful to create complex systems without physically needing to iterate through designs. It also supports repeatability, and potential structural analysis. I fully anticipate that the skills I acquire through these CAD projects will support my future career in either the automotive or aerospace industries, where 3D design and modelling will be a crucial part of the engineering process to optimize factors like weight, cost, integrity, longevity, fluid flow, and aesthetic. In conclusion, this project utilizes, and hopes to support the use of CAD, to not only conceptualize and create components in a powerful workspace like Autodesk® Inventor™, but also to make these innovative ideas into a competitive reality.