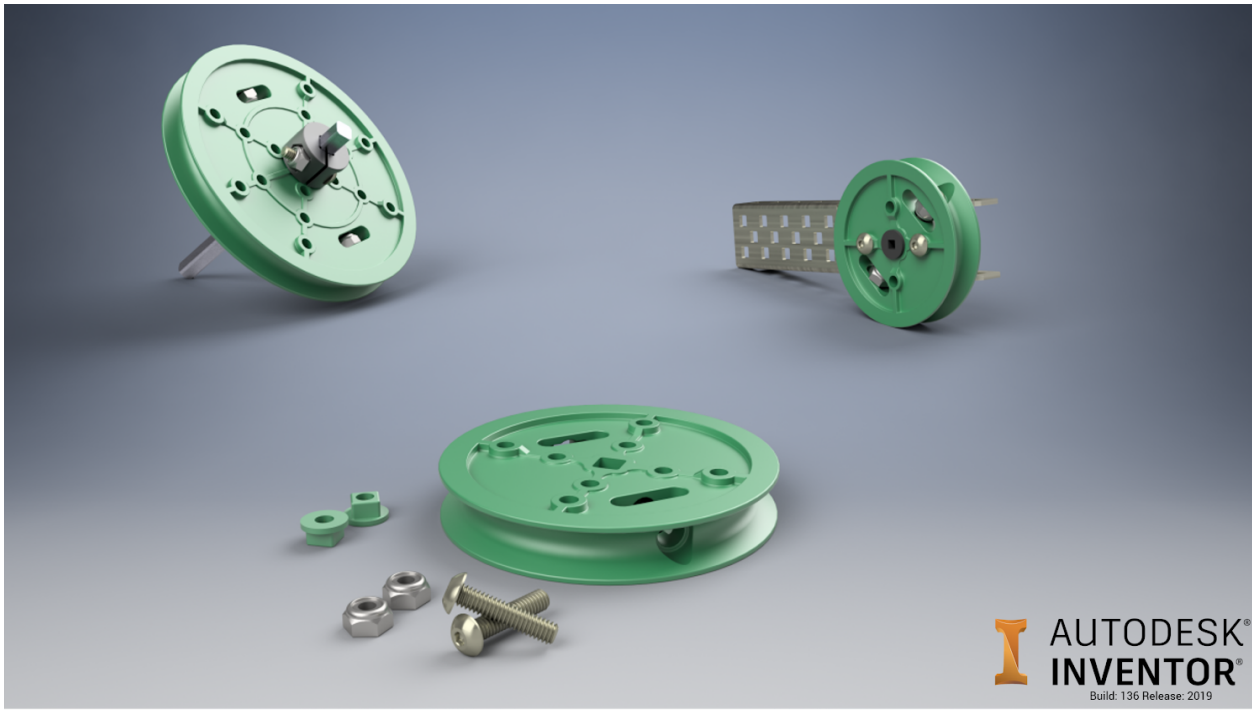
Intro

Motivation

String is a very powerful component in VEX robots, however, it is often underused due to poor hardware support.

String can offer a wide range of benefits over gears or chain, but teams rarely make use of it.

Because of this, I have designed the Advanced Pulley Motion Kit (APMK) to enable the creation of mechanisms that use string to its full advantage.



Design

Initial thoughts and defining requirements

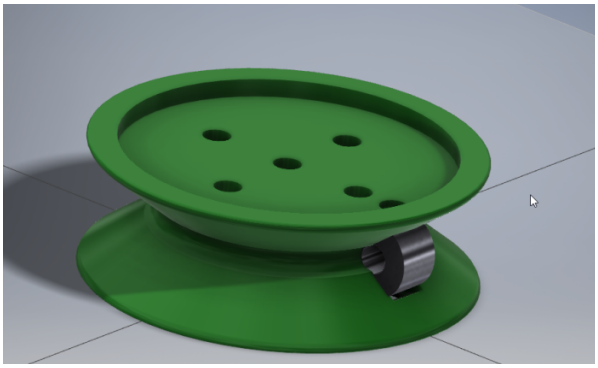
Requirements:

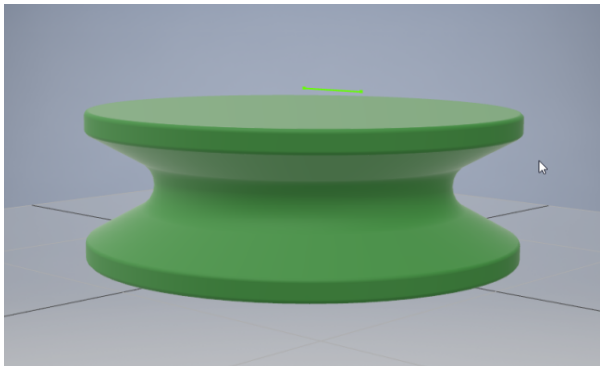
- Versatile options for driving a mechanism
- Easy to use.
- Lightweight.
- Advantageous over traditional methods.
- Allow mechanisms that aren't feasible with current VEX hardware.

Pulleys that allow string to be fixed down in place were the obvious choice to achieve these requirements; efficiently, simply, and elegantly, as per the challenge requirements.

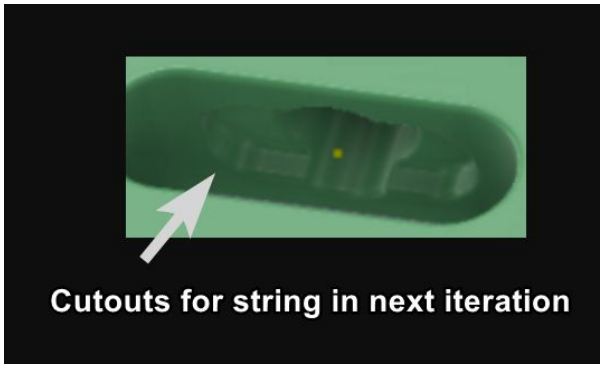
Iterations

Pictured are some of the designs I experimented with:



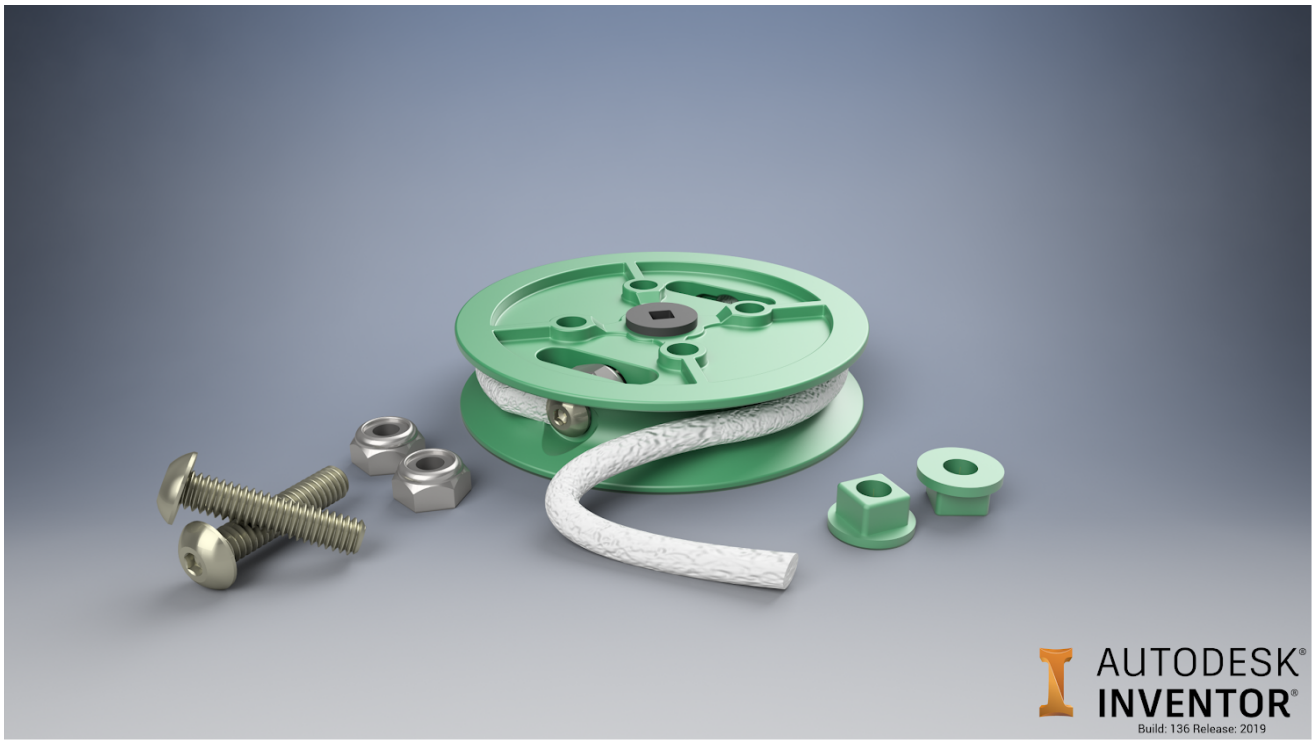


The first iteration was a yoyo-shaped pulley, with a slot for a collar to be inserted to lock onto the string, however, this was soon disregarded. As I got closer to the final design, I 3D printed a prototype, finding issues with the axle bore, and nuts getting in the way of the string. 3D printing allowed me to find these issues quickly, and solve them easily.



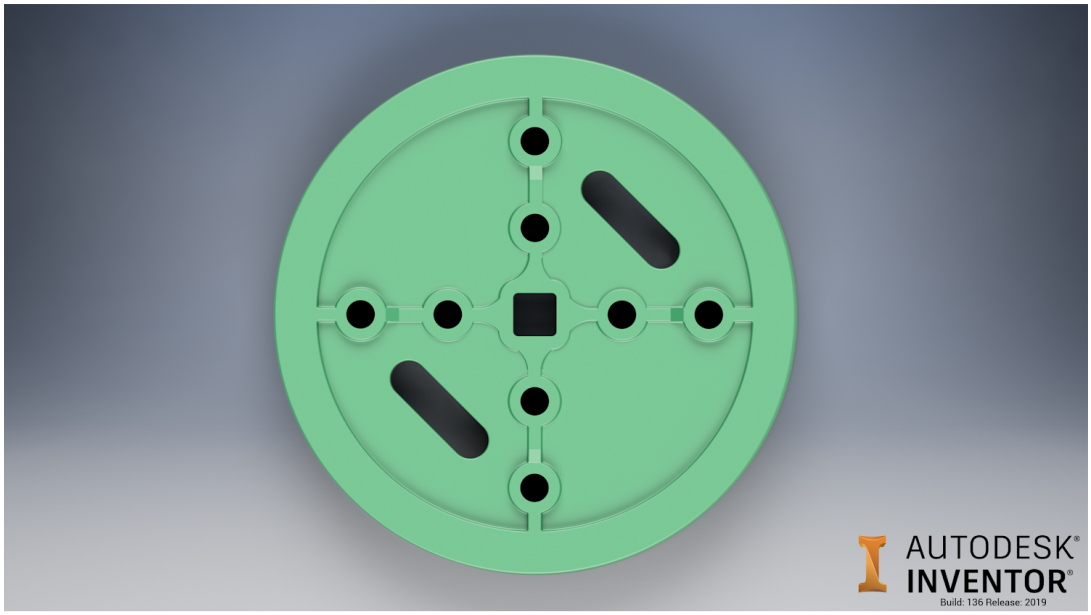
Final Design

The final design, pictured below, allows string to be inserted through holes in the circumference, followed by a screw, fastened with a nut in the slot below, clamping the string in place.



The design includes mounting holes for fastening to c-channels, gears, sprockets, etc.

The pulley also has a standard High Strength bore, compatible with HS Axles, free-spinning inserts, and metal shaft inserts, allowing the pulley to drive a variety of mechanisms.



Usage of Inventor

Autodesk Inventor Professional 2019 (Build:136) was used to design the APMK.

The basic shape was created with the revolve feature on a sketch on a plane around an axis.

I then tweaked the initial sketch to adjust the shape. The dimension tool helped me easily adjust dimensions to trial shaped pulleys.

I used a sketch on the top surface, adding mounting holes, stiffeners, and a High Strength bore.

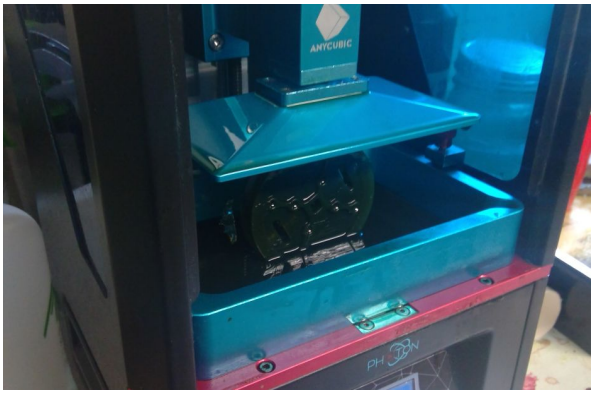
I used one sketch for multiple extrusions by using a shared sketch. To make standard HS inserts compatible with the pulley, the stiffeners were lowered to accommodate the height of the insert.

The mounting holes closest to the outside circumference needed to be flush with the edge of the pulley. I offset a plane perpendicular from the top of the pulley, creating a sketch and utilized the revolve tool to create a recess in the stiffeners.

Using the Fillet tool, the corners were rounded. To showcase the pulley with string, previously unknown CAD features were required, I learned these via the Autodesk forums. To create the string, I sketched a circle with the inner diameter of the pulley plus the radius of the string, creating another sketch on the plane perpendicular to the first. I used the project geometry tool to project the geometry and work points used in the first sketch to be able to create a circle with the diameter. This allowed me to use the sweep tool, utilizing the circle and the path for it to go along. In order to make the string seem realistic, in the renders the result of gravity was needed to be shown, in order to do this I created a 3D sketch and used the spiral tool to create another path for the circle to follow.

Fabrication

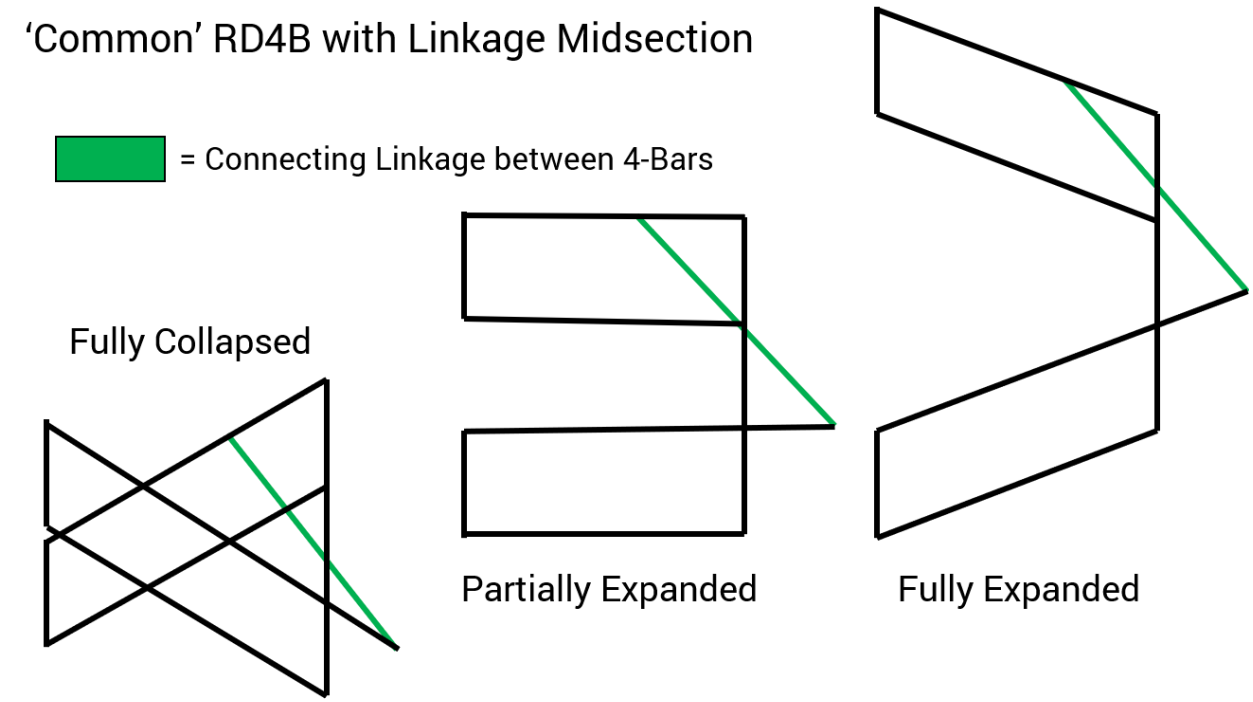
To 3D Print the APMK, we used the Anycubic Photon resin printer. Resin printing the part allowed us to get a far more detailed print, compared to traditional FDM 3D printing. We initially printed an earlier iteration, which helped us greatly in the design process to help catch issues, this earlier print is pictured below.



Examples of Part Usage

RD4B

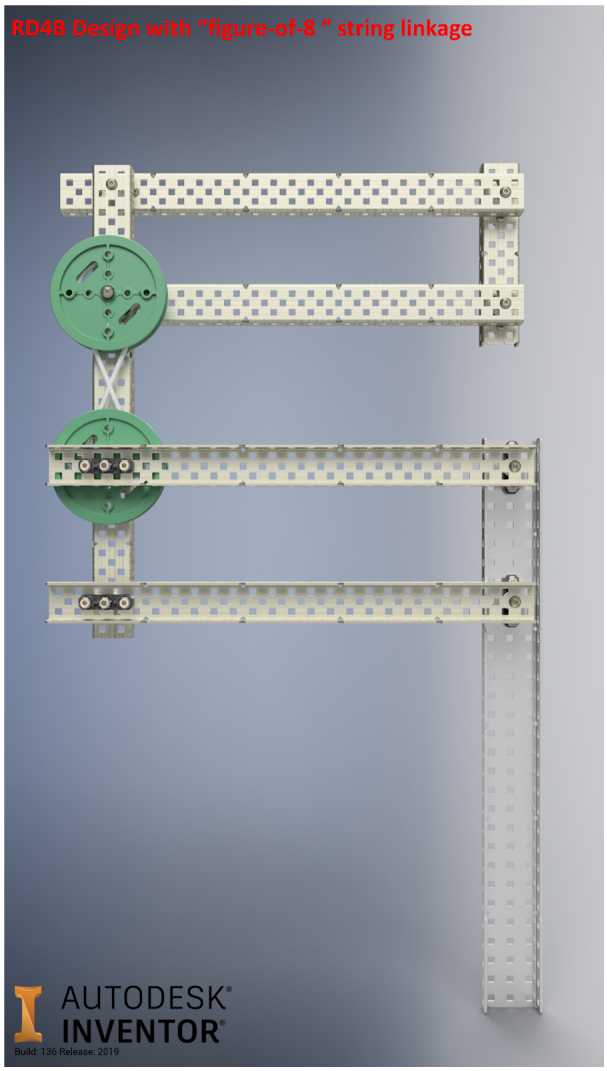
The RD4B is a very popular lift, however, many common methods of construction aren't efficient.



One of the biggest challenges is to make the 2 stages of the lift move in opposing directions. This is often done with a gearing system, however, this has a number of disadvantages, such as:

- High Friction.
- High Backlash.

The APMK can be utilized to create a figure-8 pulley system offering a lighter, lower friction solution. The tension in the string also minimizes backlash.



"Stringbar"

A common challenge in VEX robots is to keep the effector at end of an arm parallel.

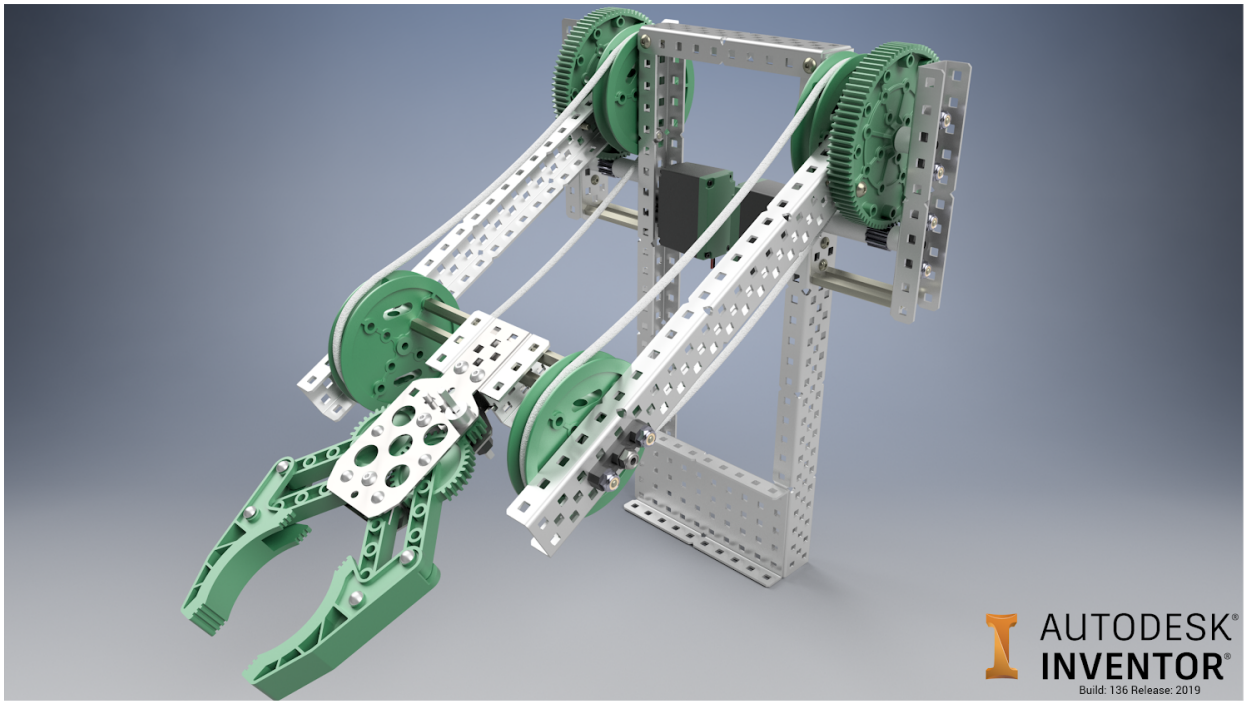
The 2 most common designs to achieve this are:

- A parallelogram 4 bar linkage.
- A "chain bar".

The APMK allows a similar design to a "chain bar", replacing chain and sprockets with string and pulleys. However, the string bar has several advantages over a chain bar:

- Lower friction
- Lighter
- Less backlash

For mechanisms that don’t undergo large amounts of stress, a string bar is almost always a superior option to a chain bar.



Rotational to Linear Motion

The traditional method for creating linear motion from rotational motion is a rack and pinion system, which is overkill for many mechanisms.

You can attach an APMK pulley to a mechanism on a linear slider to power it with rotational motion.

Using the APMK allows:

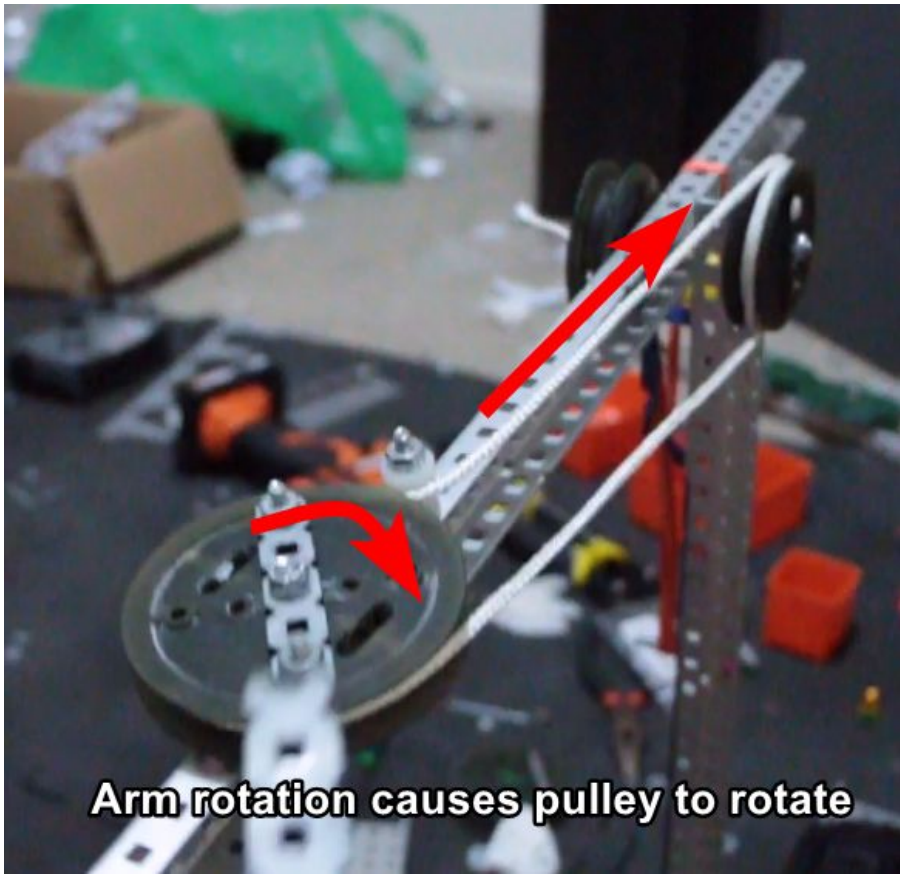
- Wider variety of mounting options.
- Lower friction than rack and pinion systems.
- Simpler design.

The APMK Pulley can be used for mechanical advantage, making it applicable in higher-force mechanisms.

Simultaneous dual-axis motion

Due to the flexibility of how string can be mounted and routed, it can easily be used to transmit power across 2 axes, allowing for very versatile design usage.

Below, string is tied down to both pulleys, so as the arm is raised, the string pulls on the top pulley, rotating the top joint.



Conclusion

I aspire to go into a career in the engineering field, where CAD is a core tool. My previous CAD experience was largely based around assembling robots with pre-made parts, so I had little knowledge with creating parts from scratch. Competing in this challenge has helped me expand my skills in CAD software.