VEX VRC – 2021 / 2022

Make It Real CAD Engineering Challenge

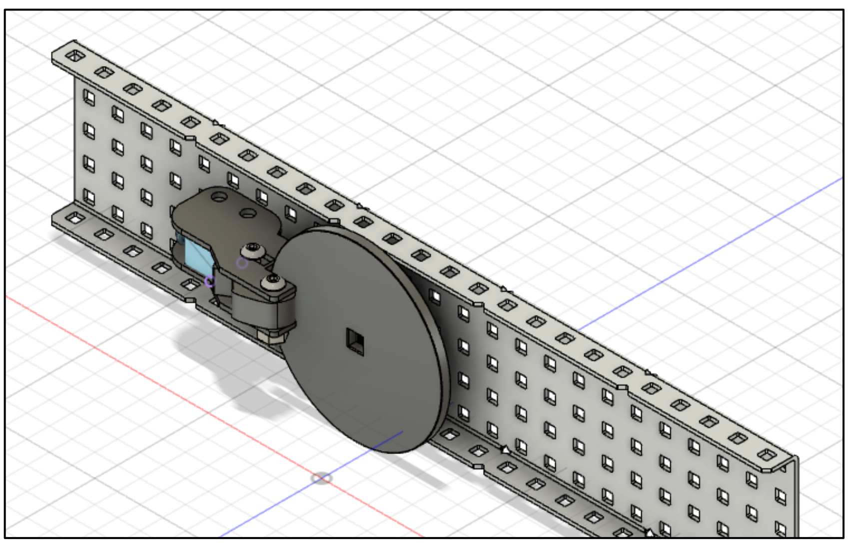
Summary Report

Team No. 84294A

Notre Dame du Sault

Sault Ste. Marie, Ontario, Canada

VEX V5 Solenoid Disk Brake



By: Liam, Luc, Nicholas, Tieran, Ella, and Gabrielle

Word count: 981 (without title page and image captions)

1) Introduction

We are team **84294A** from Notre Dame du Sault in Sault Ste. Marie Ontario, Canada. This year, we are competing in the VEX VRC High School division. While building our robot this year, we found that the V5 motors could not always hold the arm on our robot in place when we picked up the heavy mobile bases. With this problem in mind, we went to the drawing board to design a new brake assembly to hold the arm in place with more force than what the V5 motors could provide.

We call the new part the "**V5 Solenoid Disk Brake**".

2) Explanation of the New Part

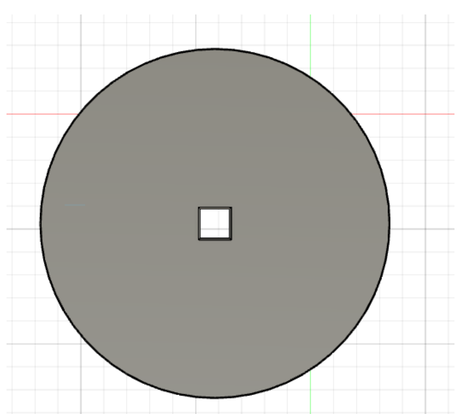
There were several design criteria for the new part:

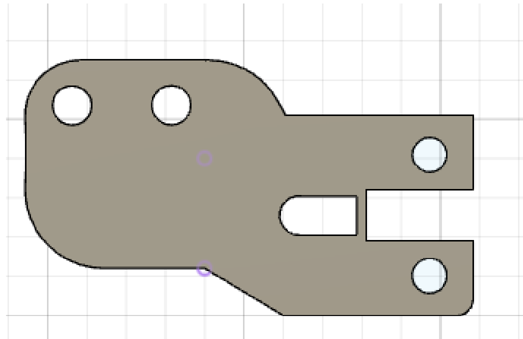
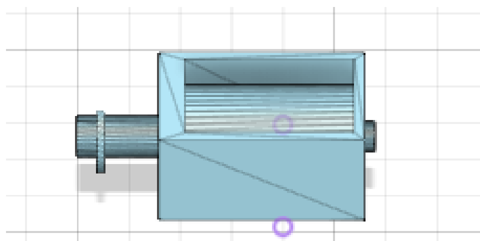
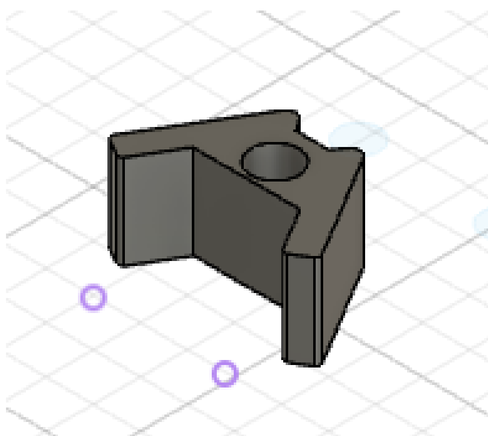
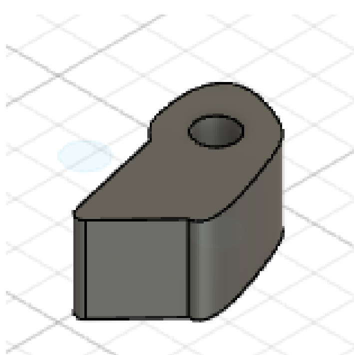
- It needed to be strong enough so it can handle the rotation forces (torque) of the arm
- It needed to be compact and integrate into existing VEX pieces so it could be used on the V5 platform
- It needed to be robust and reliable with as few parts as possible.

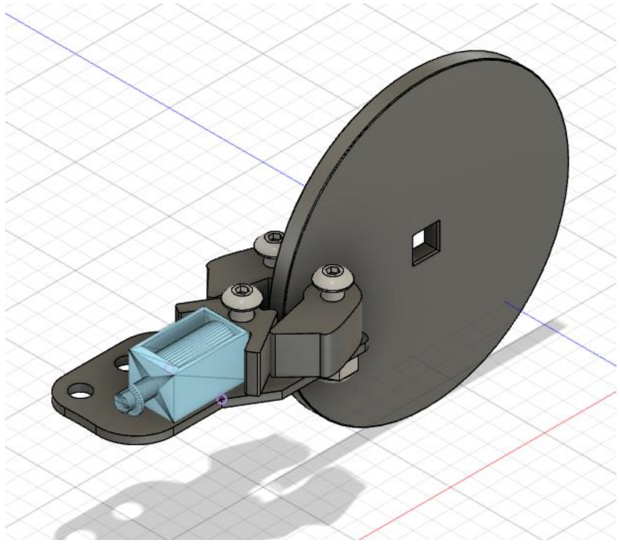
Our final part consists of the following components:

- one 4-inch diameter disk brake
- two cover plates (top and bottom)
- one 5-volt push-type solenoid that can be powered from the V5 3-wire ports
- one wedge to transfer the force from the solenoid to the cams
- Two cams to clamp down on both sides of the disk

The components for the **V5 Solenoid Disk Brake** are shown in the table below.

Part	**Picture**
4" Disk (1 required)	

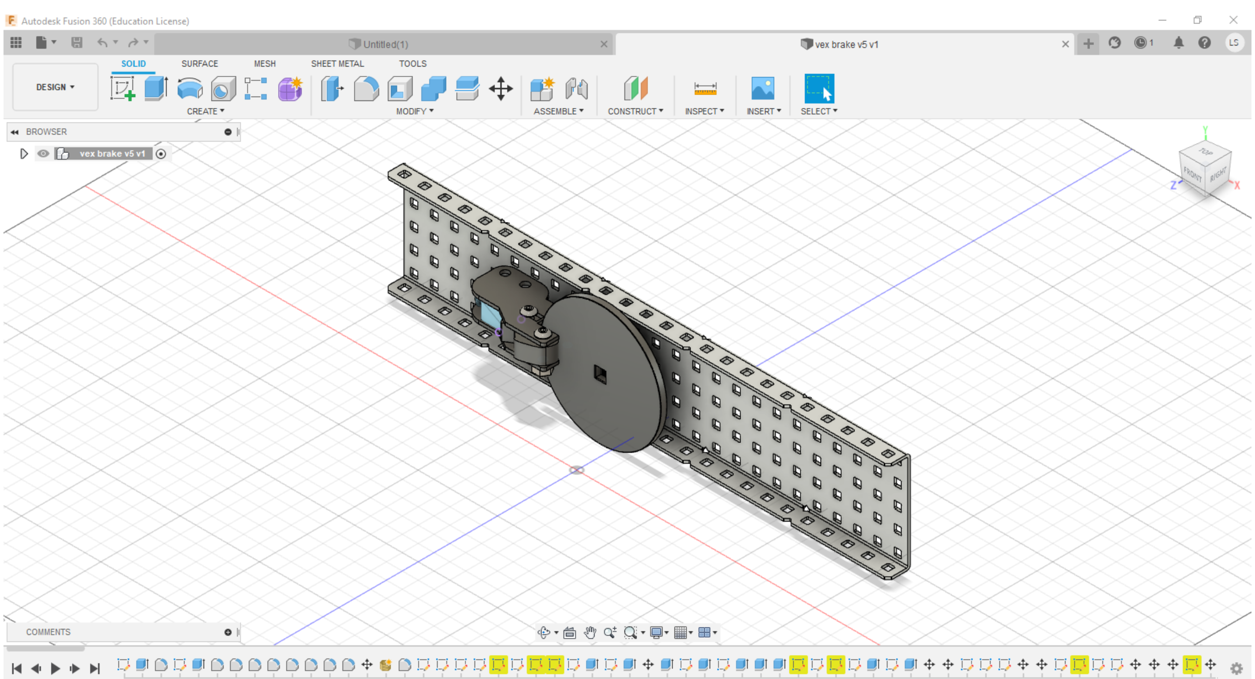
Part	Picture
Cover Plate (2 required)	
Solenoid (push-type, 5-Volts)	
Wedge (1 required)	
Cams (2 required)	

Part	Picture
Assembly	

3) Software

To design our part, our team decided to use Autodesk Fusion 360 version 2.0.11894 (Educational License). Out of our three options (Autodesk® Fusion 360™, Autodesk® Inventor®, or Tinkercad™) our team decided to use Fusion 360 since it is commonly used in the robotics industry and we had experience with this program as we used it for our robot design process.

Below is the completed model shown in the Fusion 360 program.



4) Design with Fusion 360

Throughout the design process, there was a lot of prototyping and re-engineering. We started with the 4 inch disk-brake then built up the caliper around it. We imported a 3D solenoid STL file to use in the design. Several design iterations were required. At first, we used hinging connections between the cams and the solenoid however we realized that we would need tiny pins to hold the cams thereby creating a more complicated and fragile design. In our next iteration, we tried to simplify the mechanics. We used a wedge that would slide forwards in slots to push the cams into the disk brake.

Our final design used the slide wedge concept and after a few variations of different cam shapes, the **V5 Solenoid Disk Brake** worked well and met all of our design criteria as initially established.

In creating the above components, we used the following features of Fusion 360:

- Line (this was used to create the 2D surfaces)
- Extrude (this creates a 3D volume, from a 2D surface)
- Centre-Diameter Circle (this makes a perfect circle with the centre located at a specific point)
- Spline (this was used to create complex curves for the cams)
- Chamfer (this was used to create smooth edges on all the individual parts)
- Combine (this was used to combine parts into a component)

5) Fabrication of the Part

In order to test the design, we fabricated the **V5 Solenoid Disk Brake** using a 3D printer, a 5-Volt solenoid, and existing VEX hardware (bolts, spacers, and washers).

All the components were printed using 20% infill of PLA plastic material. We found that using an extruder temperature of 197 degrees Celsius provided the optimal printing quality.

Once the parts were printed, we assembled the unit and mounted it to an aluminum VEX C-channel.

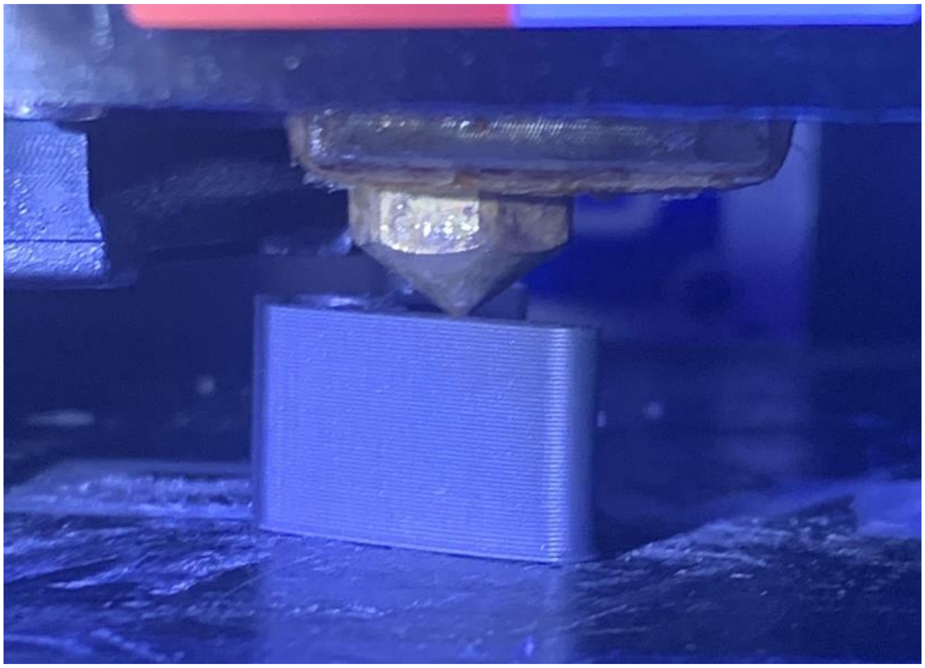


Photo 1: Printing the Wedge on the 3D Printer.

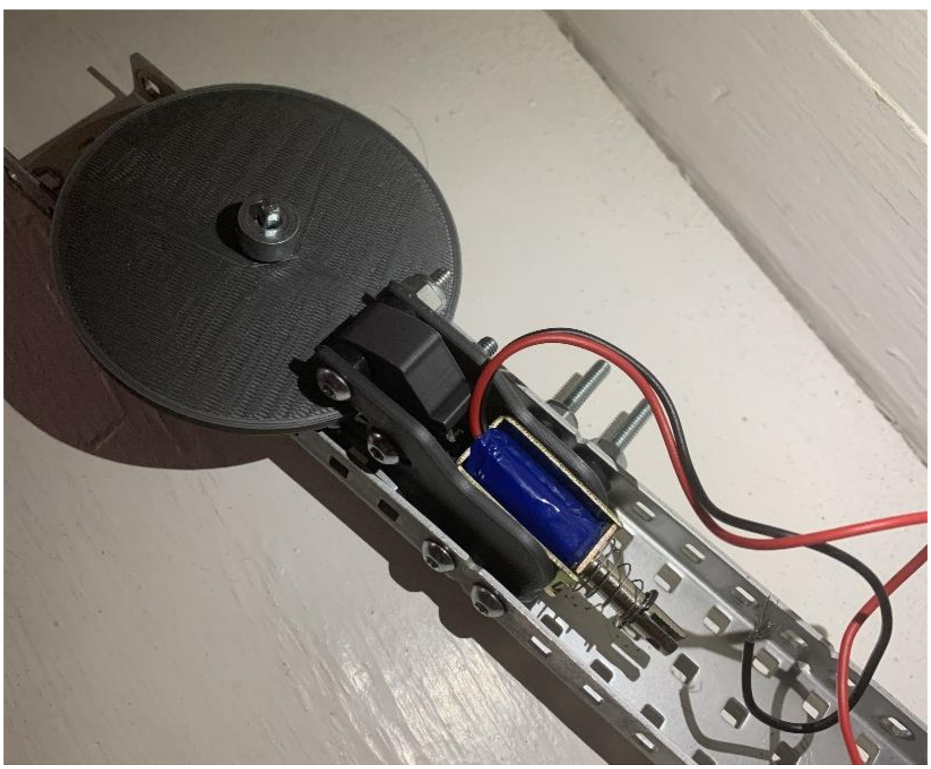


Photo 2: The final product, mounted on an aluminum VEX C-Channel.

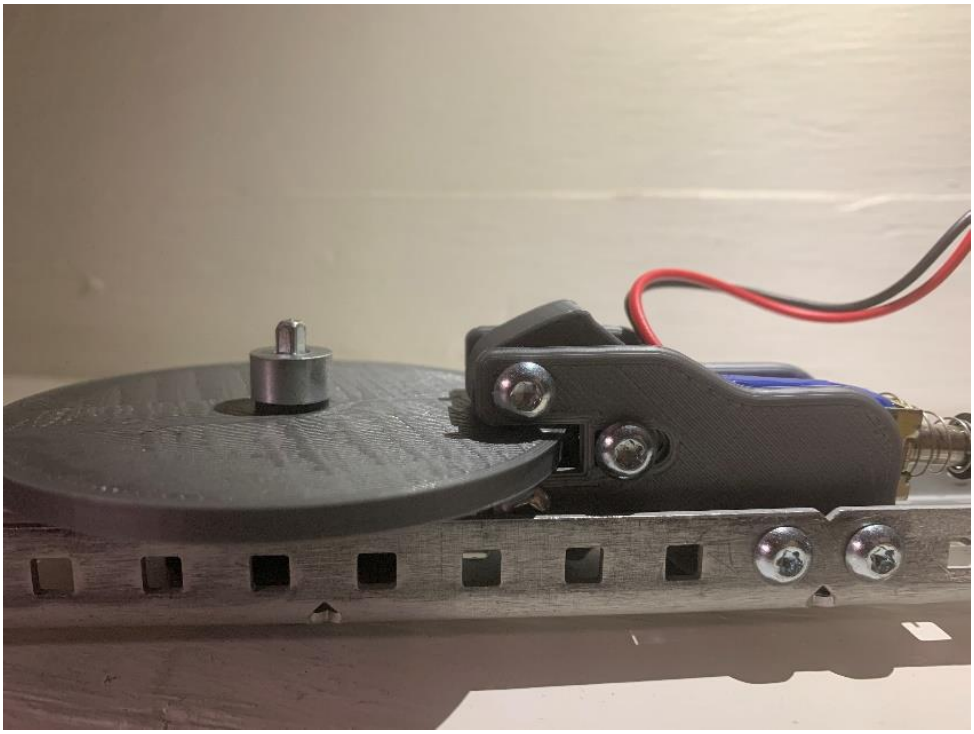


Photo 3: Side view of the final product, mounted on an aluminum VEX C-Channel.

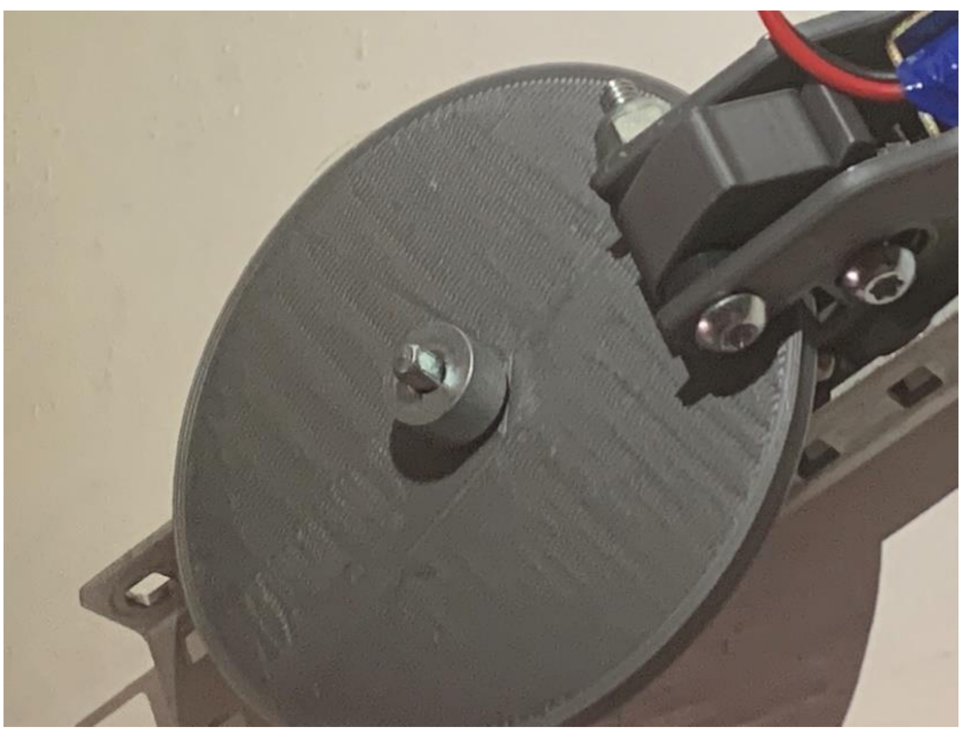
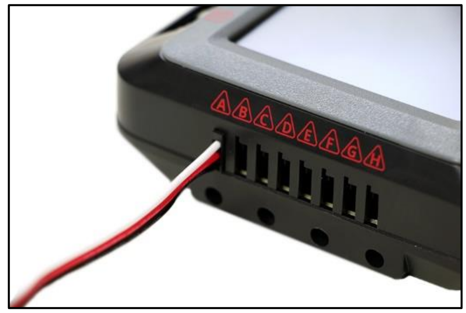


Photo 4: Top view of the final product showing the cams pushing on the disk-brake.

The assembly fits inside a standard VEX channel and can be secured using standard vex nuts and bolts. This design worked reliably and was able to apply considerable clamping force to the disk. It was compact and integrated well with existing vex components.

The operation of the **V5 Solenoid Disk Brake** requires a 5-volt power supply from the V5 Brain. This voltage is available from the 3-wire ports on the Brain (shown in photo to the right).



6) Conclusion

This was a fun project and we were happy with the final product. We do feel it could be improved if the cams were constructed from a rubber material rather than PLA plastic from the 3D printer. Rubber cams would create more friction and therefore better stopping/holding power.

Another use for this part includes releasing spring-loaded (or elastic) mechanisms which would also be beneficial in the robot design process. This can also be used to stop fast-spinning flywheels to reduce the stress on VEX motors.

In designing this part we learned a lot about the iterative design process which is a key part of good engineering design. It starts with a basic concept and is refined through trial and error, prototyping, analysis, and problem solving. Many of our team members have an interest in pursuing engineering and design-oriented careers where this process will be used.

We also became more proficient using the Autodesk Fusion 360 software. Now that we are more comfortable with the program, we will use it for future design development projects.

Finally, we now have a greater appreciation for the complexity of cam design. Through the various prototype designs we created with this project, we learned how the different shapes and angles of the cam affect the performance of the **V5 Solenoid Disk Brake**.