A common problem in the VEX robotics competition and lots of engineering applications is finding the ideal gear ratio to minimize time taken to actuate a mechanism. First, calculations must be done to find the ideal gear ratio for the perfect speed-torque balance. Next, the correct size gears have to be purchased or fabricated. This is where VEX teams are limited. There are only four sizes of gears, limiting teams to 25 gear ratios. Sprockets and chain add 12 more options, but chain cannot be used in some applications, such as high torque applications. 37 might seem like a lot of options, but these ratios span a huge range, so it can be difficult to fine tune. Compound gear ratios increase the possibilities, but gearboxes quickly become bulky and plagued by friction. Our solution is a continuously variable transmission (CVT) that allows teams to utilize any gear ratio between 3:1 and 1:3. Teams would be able to fine tune their gear ratios to optimize mechanisms without the drawbacks of traditional gearboxes.

The design features two cone-shaped metal gears, each with twenty-four teeth running along their length and a square shaft hole through the center. A 4 x 2.25 x 2 inch acetal box with removable lid has two shaft holes for shafts to hold the cones in place. The box also has ten mounting holes and two slits on the top and bottom for screws to be inserted to hold the belt in place to select the ideal gear ratio. The belt is made of rubber and has a jagged inner edge to match the cones. Assembly of the parts requires two shafts, two 2 inch screws, two keps nuts, ten large black spacers, two lock nuts, the cone shaped gears, belt, and box. The screws are inserted into the slots and tightened into position about .25 inches apart with the keps nuts, then the spacers and lock nuts are added onto the screws to create a pair of idlers to keep the belt in place. The belt is positioned between the screws, and the gears are positioned in line with the shaft holes. Shafts are fed through the holes and gears to hold everything in place. Finally, the lid is slid on, completing assembly. The design is compact enough to fit inside a traditional gearbox, allowing for compound gear ratios where space otherwise would be an issue. The screws can be readjusted quickly to change the gear ratio until it is just right. Advanced teams could opt to use shafts instead of screws for the idlers and design a mechanism to slide the belt and change gear ratios during a match. The CVT can be utilized wherever a precise gear ratio would optimize robot performance. For example, instead of choosing between a 100 or 200 rpm drive base, a team could use the CVT to create a 163 rpm drive base for optimal control and speed. In the assembly attached to this entry, a simple arm with a 1:7 torque gear ratio uses the CVT to allow for any ratio between 1:21 and 3:7.

To create the parts for this entry, we used Autodesk Inventor Professional 2017. We started with the conical gears, making a triangle in sketch mode, revolving it to make a cone, sketching and extruding the shaft hole, sketching and symmetrically extruding one tooth, using the chamfer and fillet tools to form it into a rounded triangle, then using the circular pattern tool to create twenty-four identical teeth. For the belt, we sketched two “slots”, extruded it to make a belt, sketched and cut away a single tooth, then used the rectangular and circular pattern tools to create 154 identical teeth. We used the sketch, extrude and shell tools to create the box. We used the material tool for each part to make the appearance of each accurate for its material. To showcase the part in a VEX application, we made an assembly and used the STEP files from vexrobotics.com to create a robotic arm assembly with our CVT. We adjusted the settings in the view tab to remove work features and make the shading and perspective more realistic before exporting images to upload with our entry. The orientation cube in the top right corner helped aligned the parts for isometric, top, and side views.

This project was great practice in both designing and modeling. It took some time to work out the dimensions required to make everything work while being compact and efficient. This design has multiple components, each of which required lots of steps to model. It was definitely good to practice using all the various tools that Inventor offers in both part mode and assembly mode. Specifically, we had to learn how to use the pattern tools for making multiple identical teeth, because none of us had ever used that tool before. Even after modeling three full robots, there were tools we had never used in Inventor, a testimony to its impressive capabilities and complexity. We will definitely continue to use Inventor for modeling robots and designing things in engineering class. CAD makes designing engineering solutions fast and thorough so there are less last minute modifications during the prototyping and testing phases of the engineering design loop. For example, in VRC, modeling a full robot in Inventor can reveal design flaws, allow teams to figure out dimensions before cutting material, and create a parts list for you. Inventor can even simulate moving mechanisms on your robot so you can guarantee it will work before building it. Knowing how to design and model engineering solutions is a vital skill to have in the work force, and we already have a head start. Designing parts for real-world applications is a step up from what VEX requires, but we already have the CAD skills to start making an impact and improve further and faster thanks to Autodesk for making their products free for students and VRC for giving us a worthwhile and fun engineering challenge!