NYIT Bears in VEX U
New York Institute of Technology
New York, United States
REC Foundation Online Challenges

CAD Engineering Award

NYIT has been competing in the VEX U college division for the last 5 years with our accomplishments being largely aided by advancements in technology. Amongst these major developments include improvements in computer-aided design technologies. Using Autodesk Inventor, our team has designed many parts for the VEX competitions. NYIT's career being a part of VEX has been a great experience for all of our students as well as our school.

This past year we attended the 2014-2015 VEX World Competition held in Louisville, Kentucky. We finished 16th in the world and earned the Build Award for our innovative CAD parts for both of our robots. Majority of VEX Teams that compete each year only have to put together one robot, but in the VEX U Division we have to design two robots. We have size requirements for both of the robots as well as specifications regarding the number of motors, amount of non-VEX materials, and 3D parts that we can use in our designs.

Last year, we designed multiple parts for both of our robots but were restricted to the use of two 3D parts total, both within the bounds of 3” x 3” x 3”. This year, the new Game Rules allow for an unlimited number of 3D parts within 6” x 6” x 6”. As a team, we decided to design and incorporate as many 3D parts for our robots this year to help increase the overall performance of the robots. We designed our robots all on Inventor first to make sure they would perform and would be a solid design for this year’s competition. With new game rules and majority of the points based on a team’s field strategy, the bonus of 50 points if one of your robots can elevate the partner robot makes a significant difference in the winning or losing of a match. Based on these statistics, we decided to design our small robot so it would be lightweight and have the capability of climbing up a ramp attached to our big robot.

Our small robot must have the ability to climb up a ramp designed with a shallow incline for a total of 50 additional points scored by the end of the two minute timed game. With this being a key task, our small robot would need to have tall enough from the bottom of the wheel to the bottom of our chassis in order to clear the side edge of the ramp. We initially used standoffs to connect the chassis and drive support rails, but the drive gears rubbed against them. We then used aluminum plates, but they interfered with the ramp and caused the robot to backflip off of the ramp. Doing maintenance on the drive became a mess of washers, plates, nuts and screws. We then decided that a custom piece would be necessary. It would overcome the gear hurdle and eliminate the metal pieces and washers needed with the aluminum plates. The best way to design the custom piece to hold our chassis rails together was via 3D design software. The final product would be both strong and lightweight. Our robot will be able to use these chassis braces which are stronger and simpler to use than metal, allow for a smooth climb up the ramp, and ensure that we remained within our 15” x 15” x 15” size restriction. As our design is used in conjunction with VEX parts, it can be used for any game that uses ramps (Nothing But Net) or even bumps (Toss Up). Our design could even be designed and sold through VEX if designed for VEX Robotics as a manufactured part.

As with every engineering project, there is a design process. After having built our small robot, we noticed that the present supports we used to combine the chassis rails to the drive support rail were not conducive to a well-functioning robot. As a result, we needed to design a custom support piece. The following list our design approach and the steps taken in order to create the chassis rails supports in Inventor:

1. Based on the small robot chassis rails made entirely from VEX parts, we determined that the custom pieces are equivalent to a 6-hole piece of metal. For further understanding, our chassis supports were constructed with both 5-hole and 3-hole C-Channels; the 3-hole C-Channels were used on the outside to ensure clearance for the ramp.
2. The process of the design using Inventor:
    - i. The design process (discoveries regarding the chassis support rails)
        - a. Needs to have more structural support and stability for the chassis
        - b. Needs to have clearance to climb the ramp or other high clearance point
        - c. Pieces must have: 1) the ability to hold the bars together, 2) clearance for ramp, and 3) clearance for the gears riding above the chassis top
        - d. Various ideals were visualized graphically before the final selection
    - ii. The engineering process
        - a. Measured space equivalent from 5-hole to 3-hole C-Channels is a 6-hole gap; this reference was used as the main dimension.
        - b. Chassis of the existing small robot assembly file was modified by removing the original supports: standoffs
        - c. Two Inventor file parts were created for the chassis support rails: one for the top, and one for the bottom
        - d. Measurements, in inches, were taken for: the 6-hole gap, diameters of each hole, the distance between holes, and distances for the bottom bracket
        - e. Using a series of 2D sketches made completely from geometric shapes, the basic outline of the part was created
        - f. Extrusions, 3D representations of the 2D sketches, were used with slight alterations
        - g. 3D parts were then added to the assembly file to ensure the correct measurements as well as to assess future potential modifications
    - iii. The manufacturing and distribution process
        - a. Upon completion of engineered file, part files were converted to STL files
        - b. STL files converted to print files compatible with the 3D printer
        - c. Files were printed and used on the robot chassis

While working on the chassis rails supports, from the initial standoff method to the 3D parts, we learned that even something as simple as connecting two pieces of metal together is a critical engineering process, especially when there are moving parts involved. 3D design software such as Inventor opens up a world of possibilities for structural designs. This is especially useful for members of a competitive robotics team because the general parts available for use restrict the designs that we can use. The incorporation of 3D parts helps overcome these limitations; functional creativity and imagination are the only limits. We will continue to use Inventor not only for robotics competitions, but also for our individual and group design projects that we work on during the academic year and at home. As our team is composed of mainly electrical and mechanical engineers, it is necessary for us to understand how to use CAD software for schematics and 3D design software for prototyping. Having a working knowledge of both strengthen our skillset and make us more well-rounded engineers.

The following are pictures of our two part 3D printed piece called "Chassis Rails Supports." In the below group pictures our screenshots of Inventor, our 3D printed parts in real-life (printed in black PLA), followed by mechanical drawings.

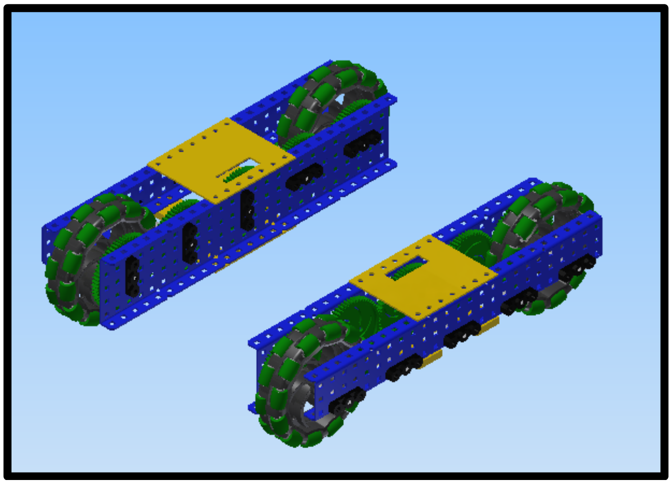
Figure 1: Chassis rails support - top

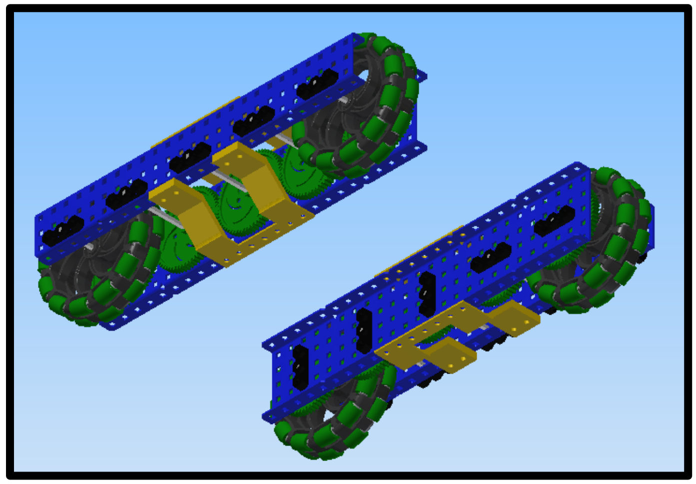
Figure 2: Chassis rails support - bottom

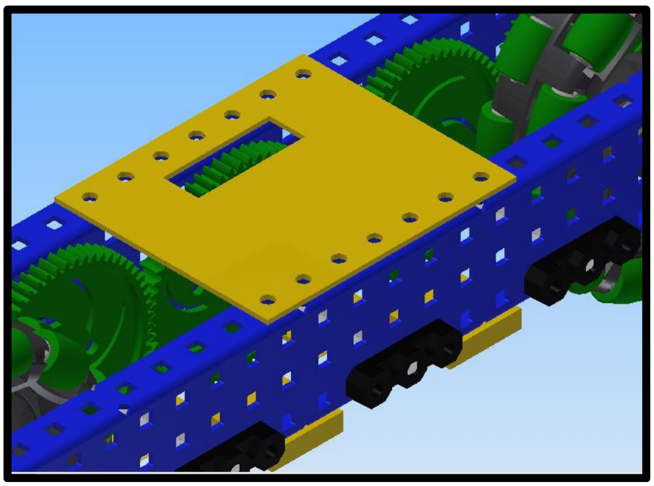
Figure 3: Chassis rails support – top close up

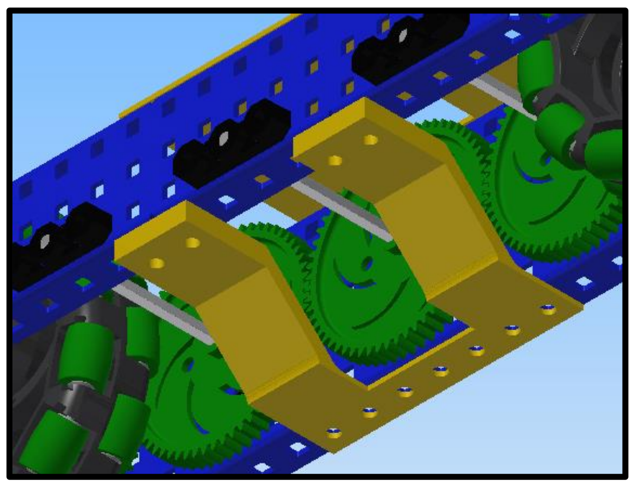
Figure 4: Chassis rails support – bottom close up

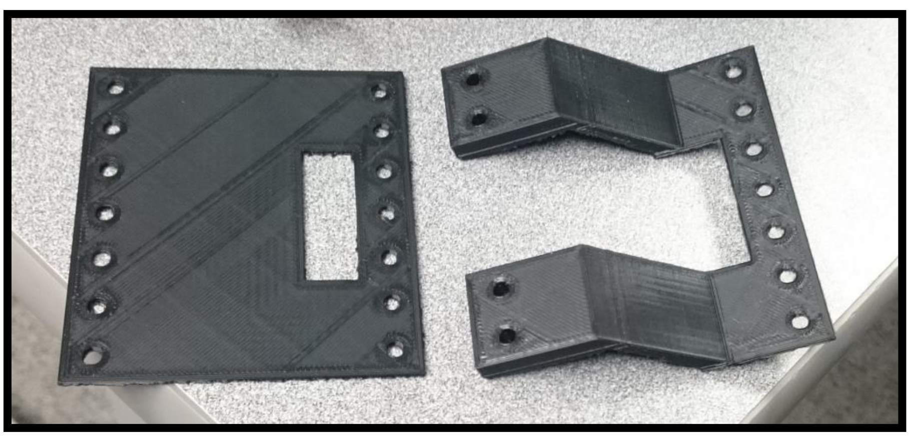
Figure 5: 3D print of Chassis rails supports

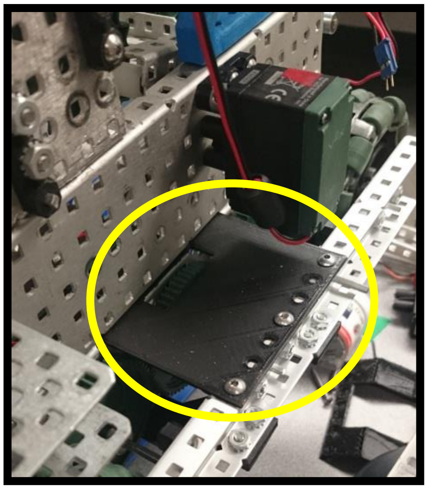

Figure 6: Top print assembled

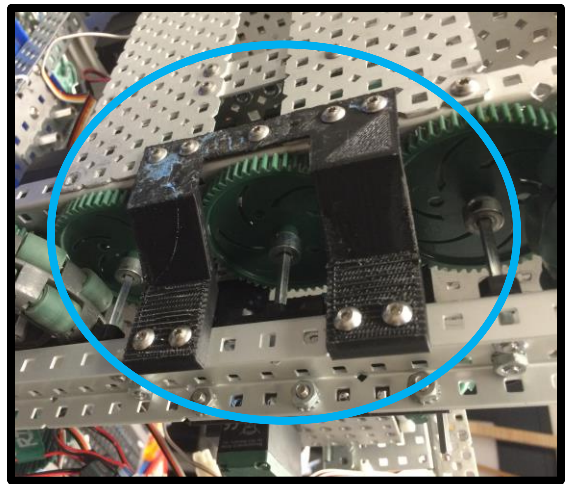

Figure 7: Bottom print assembled

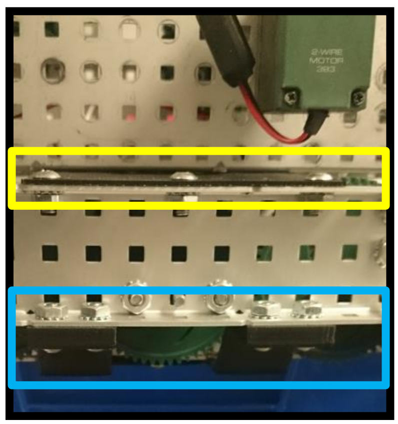

Figure 8: Completed assembly of “Chassis Rails Supports” on robot

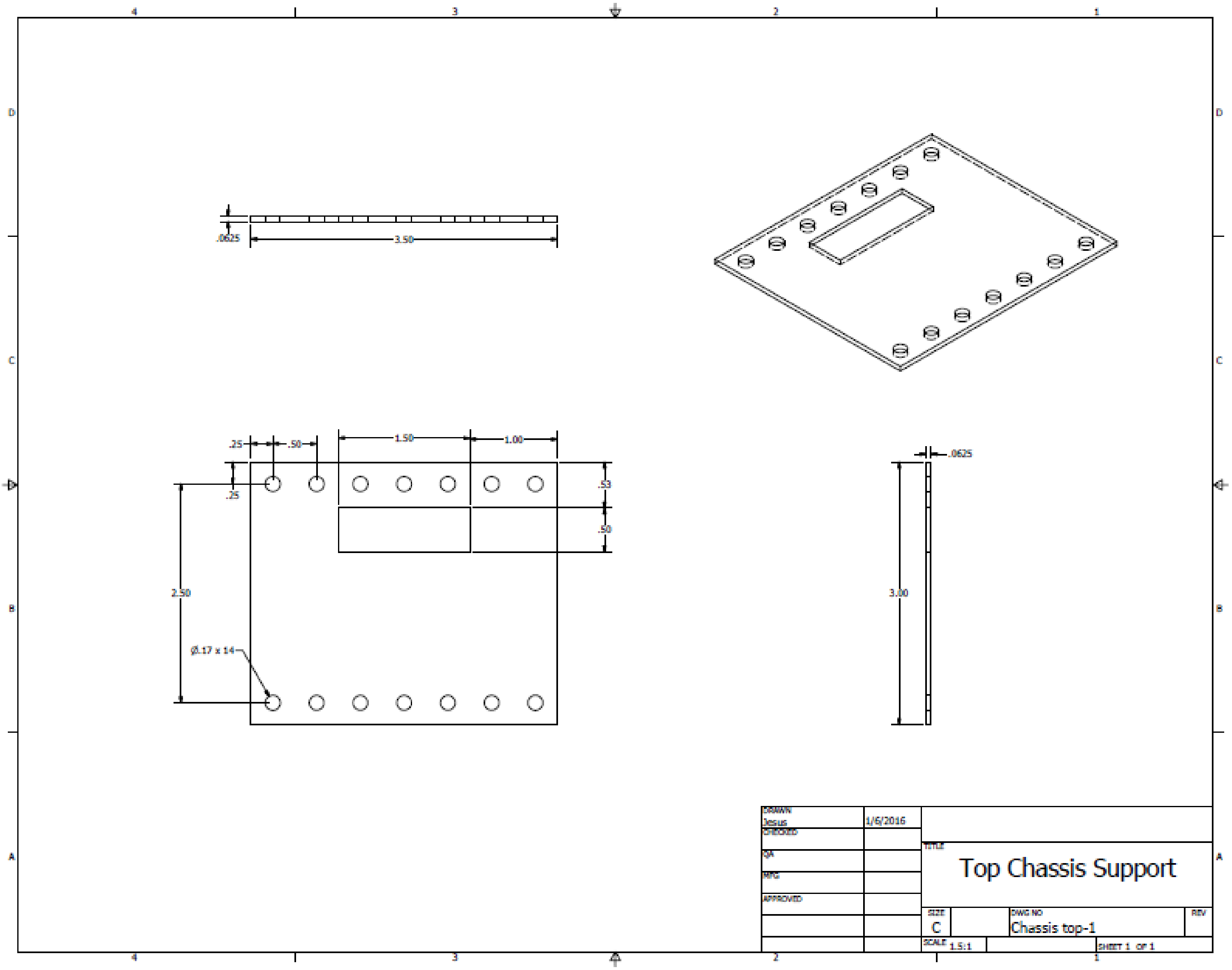

Figure 9: Mechanical Drawing of Chassis rails support – top

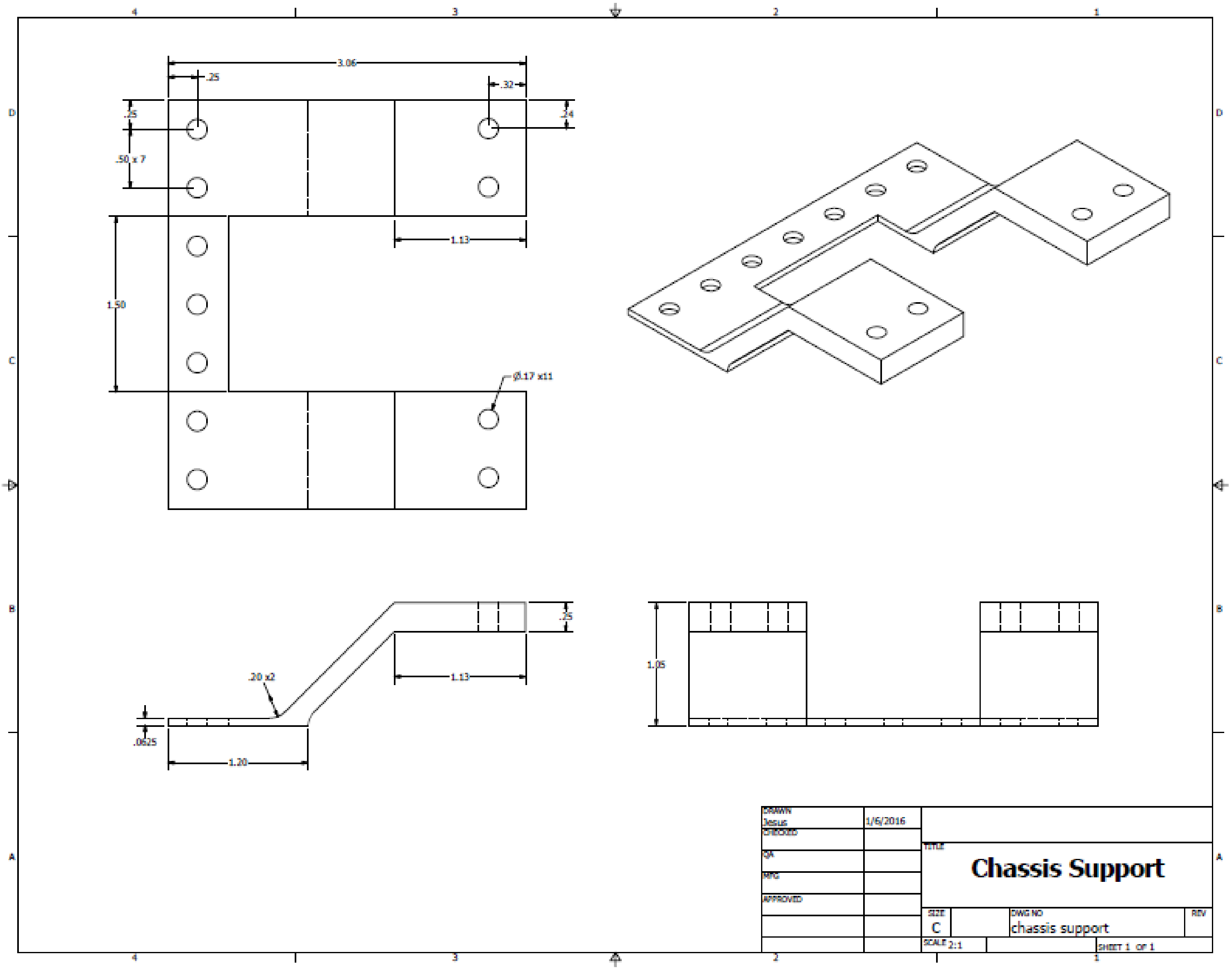

Figure 10: Mechanical Drawing of Chassis rails support – bottom