Fernando Pascual

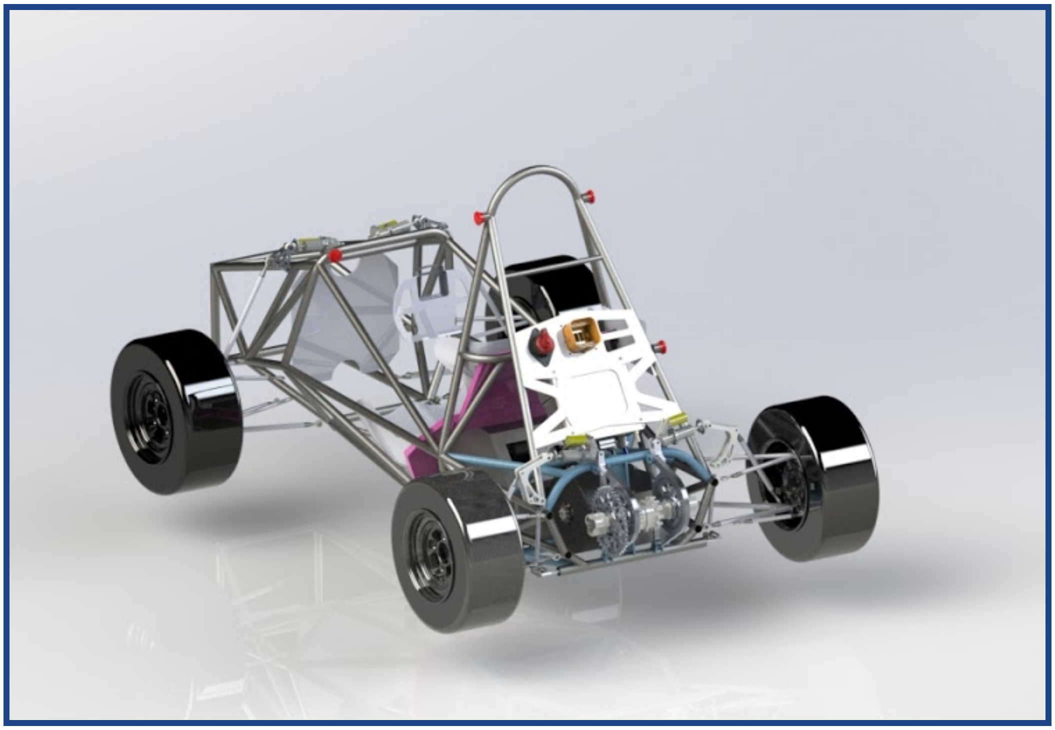
Selected Projects Portfolio

Web: nandopas.github.io

FSAE Electric Vehicle Components

Objective: My team's senior design project fully integrated the functional and mechanical systems for Columbia University's first electric racecar for Formula SAE intercollegiate racing. We integrated these systems into the chassis of an existing FSAE internal combustion racecar and lead the FSAE EV team in all mechanical engineering aspects of the racecar.

I was responsible for drive train assembly, drivetrain cooling loop, and manufacture of all components.



Final Render of Vehicle

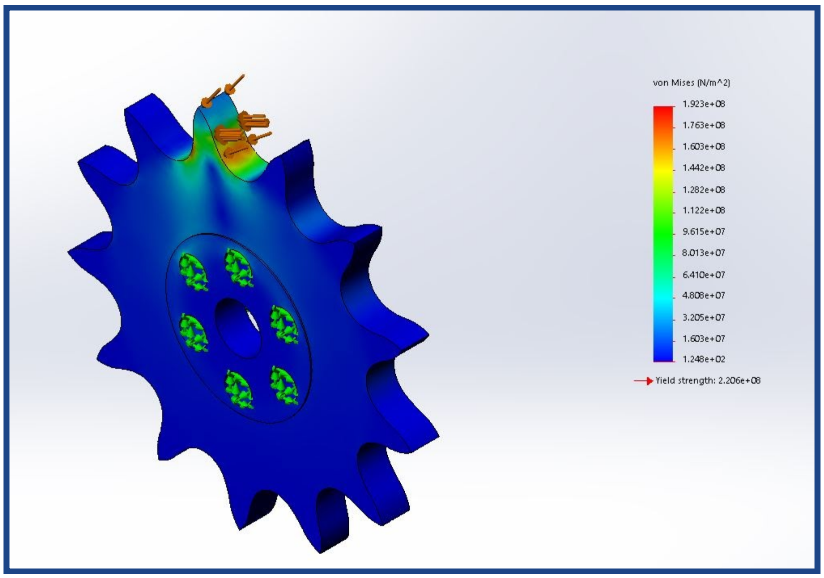
CAD Drawings/Analysis

Drive Sprocket

The drive sprocket design was based of specifications from the American Chain Association's Standard Handbook of Chains for designing a sprocket to fit a chain of predetermined dimensions. The chain used was an ANSI 50 roller chain.

Analysis conducted on the sprocket to validate its design included 2 steps. First, a 660 N load was applied to one tooth.

660 N Force Applied to Sprocket Tooth

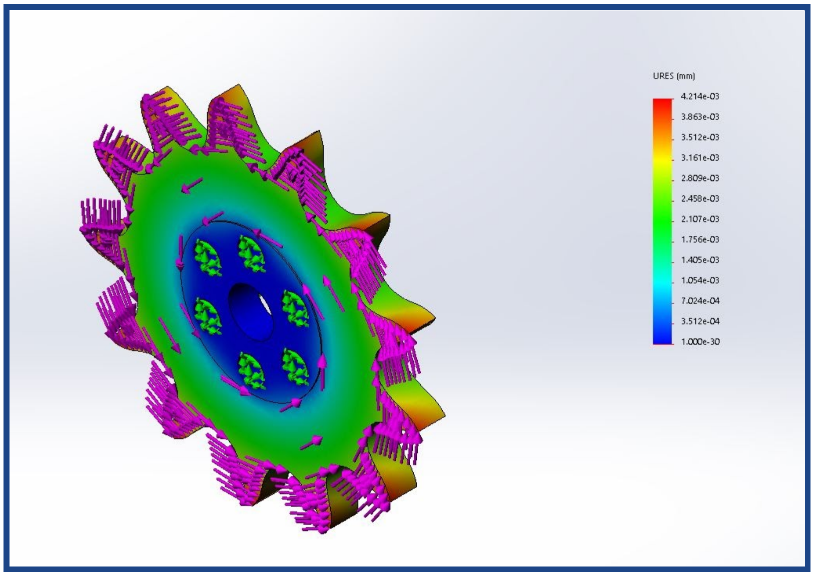


von Mises Yield Criterion (N/m2)

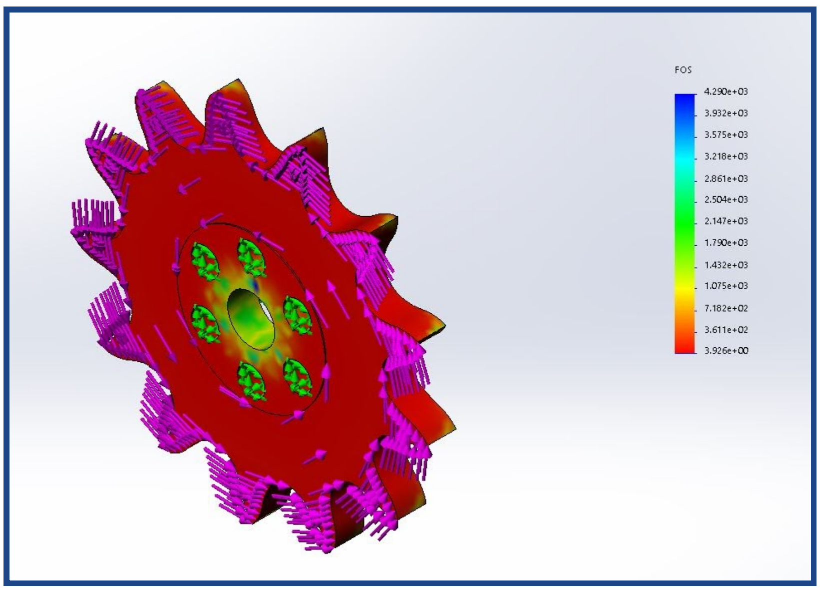
This was done to simulate the load of resistance from the wheels delivered to the chain and then to the sprocket. In reality, the chain would never act on just one tooth, the chain force would be distributed amongst various teeth, but this simplification allowed to determine a worst case scenario.

1020 steel was used for its high tensile strength and low deformation as can be seen in the deformation analysis, with no point deforming more than .02 millimeter and a uniform factor of safety plot.

140 Nm Torque Applied to Sprocket Face



Static Displacement (mm)

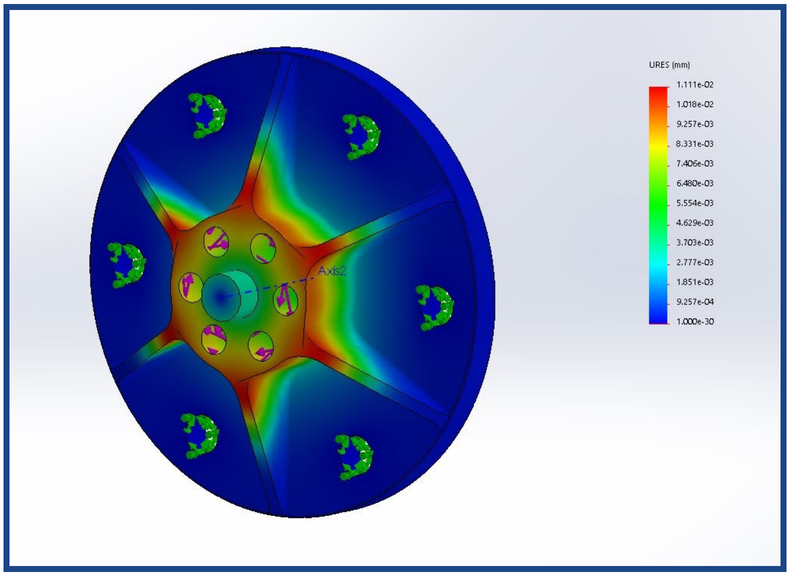


Factor of Safety

Sprocket Carrier

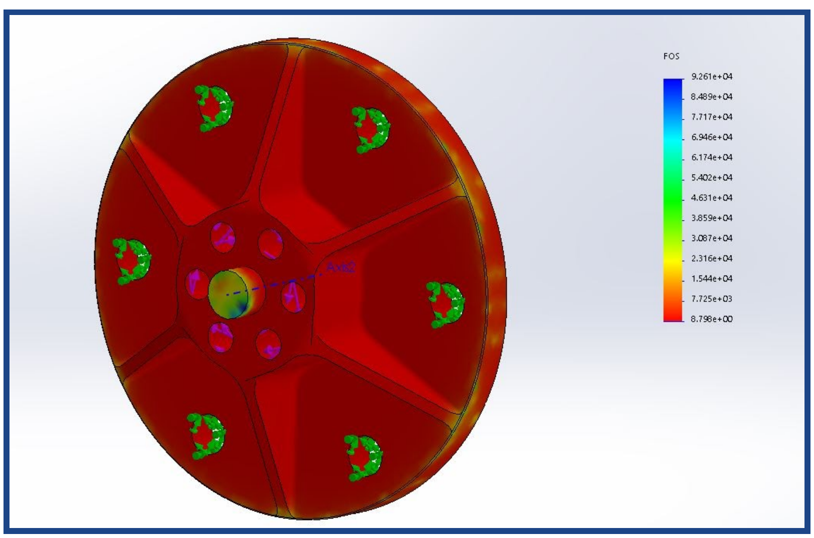
The sprocket carrier went through a similar torque simulation process as the sprocket, however, the material chosen was 7075 aluminum. 7075 has a higher tensile strength than 1020 steel, and its higher ductility was not considered as big of an issue as with the sprocket as machinability was prioritized.

140 Nm Torque Applied to Sprocket Carrier Face



Static Displacement (mm)

Even through ductility may be a concern, the deformation plot below shows a maximum deformation of 1 hundredth of a millimeter on areas that do not interfere with bolting. Suggestions for further iterations include larger fillet radii at the connection between the gussets/extruded surface and the base plate as suggested by the stress plot. Additionally, machinability should be kept in mind as the lathe chucks need to grip between the gussets to remove excess stock.

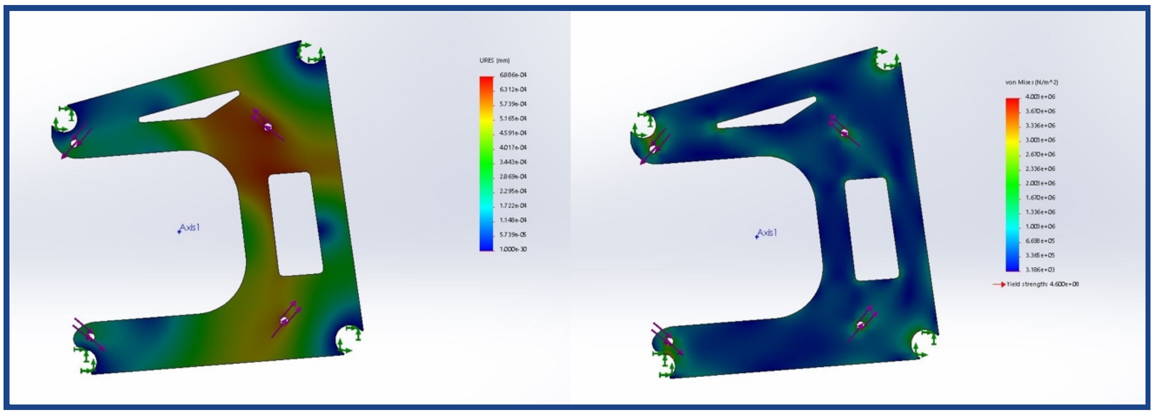


Factor of Safety - Again, the component has a high and uniform factor of safety.

Motor Mount/Clevis

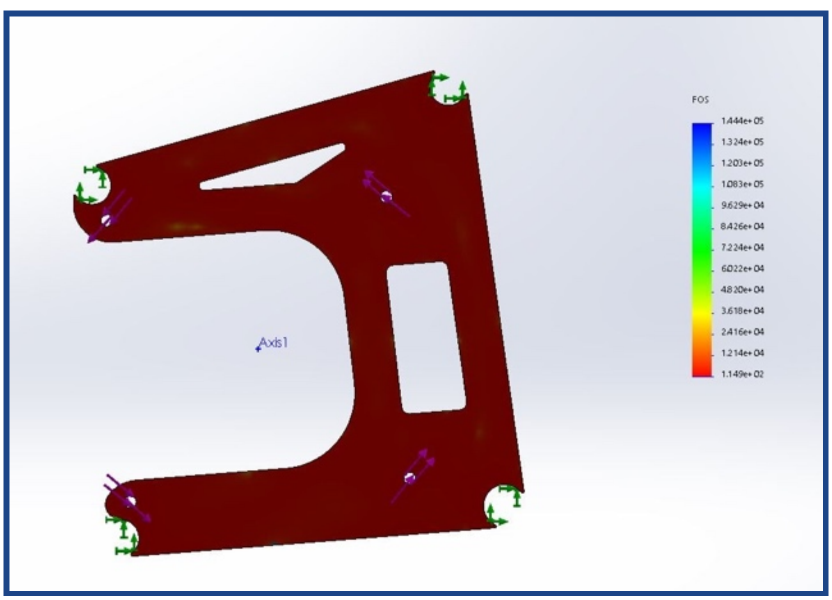
There were few FSAE rules at the time that applied specifically to electric vehicle motor mounting so instead, the maximum torque produced by the Emrax 208 motor (140 Nm) was used as a benchmark for determining the strength of the motor mounts.

As seen in the displacement graph, there was a high degree of certainty regarding the strength of the clevis. The maximum displacement was $6.886*10^{-4}$ mm. As expected, there are stress concentrations about the mounting and welding points, but nothing approaching the yield strength of the steel.



Static Displacement (mm) von Mises Yield Criterion (N/m2)

An extremely high factor of safety, 10, was used to design the clevis, which attaches the motor to the chassis. The clevis can be seen below in Fig. 12. Thus, a .25" thickness was selected for the clevis steel plate. This thinking was due to a past critical failure caused by underestimating the forces being transferred to the chassis.

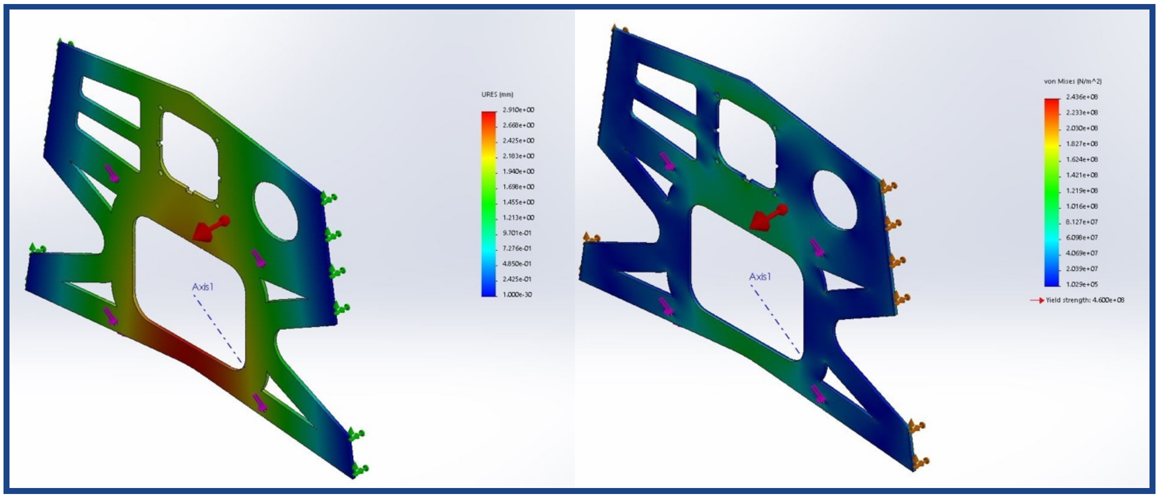


(c) Factor of Safety

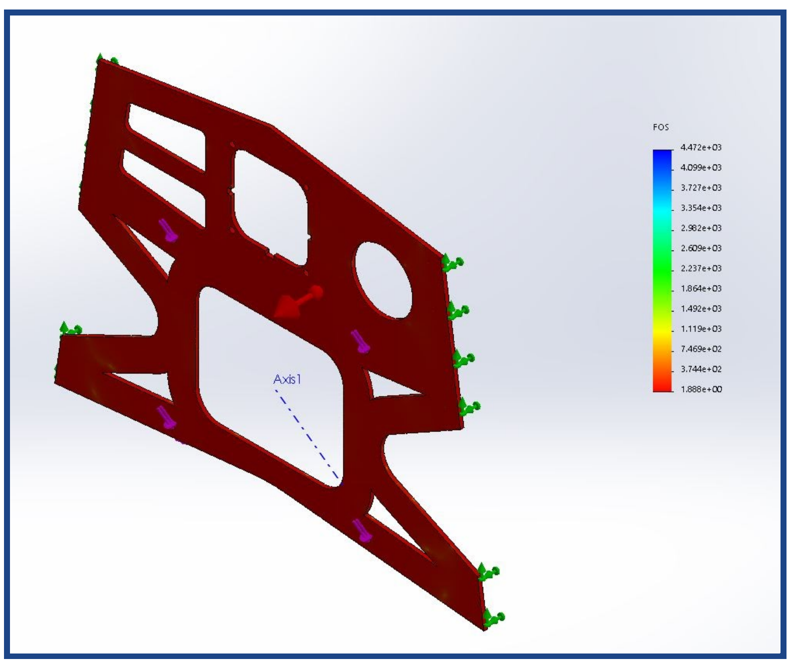
Inverter Mount

This mount was designed to hold the AC/DC power inverter and other high voltage safety equipment.

There were no FSAE guidelines at the time on inverter mounting, so it was decided the component should be able to withstand the same accelerations as the battery accumulator (40g longitudinal and laterally, 20g vertical). FEA was conducted on the inverter mount in all acceleration directions with the mass of the inverter simulated, shown below.

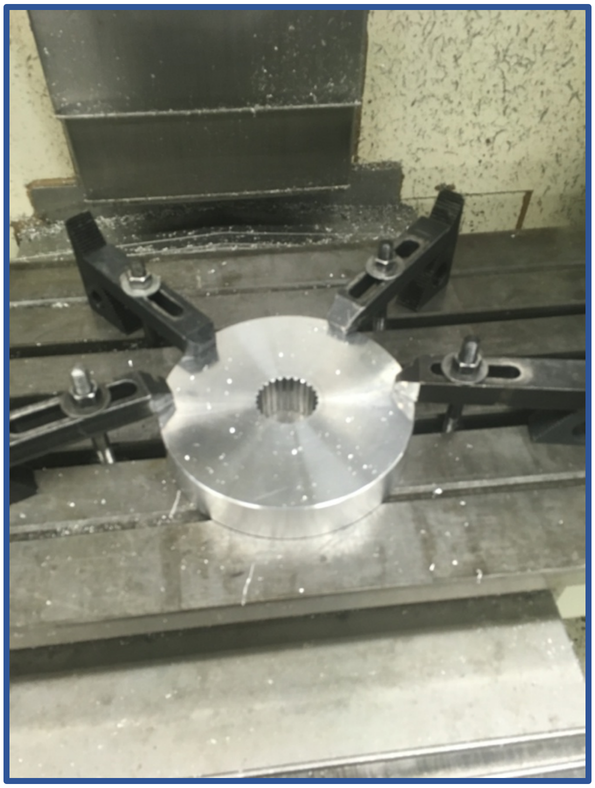
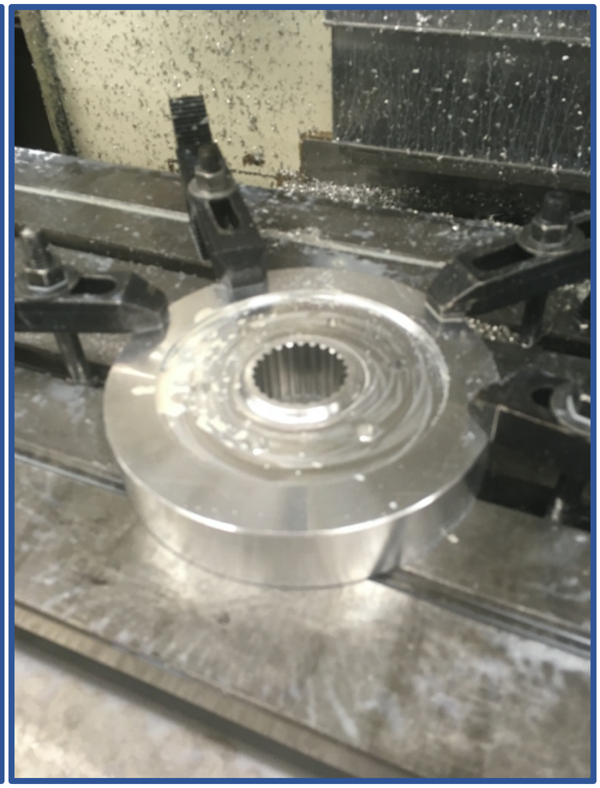
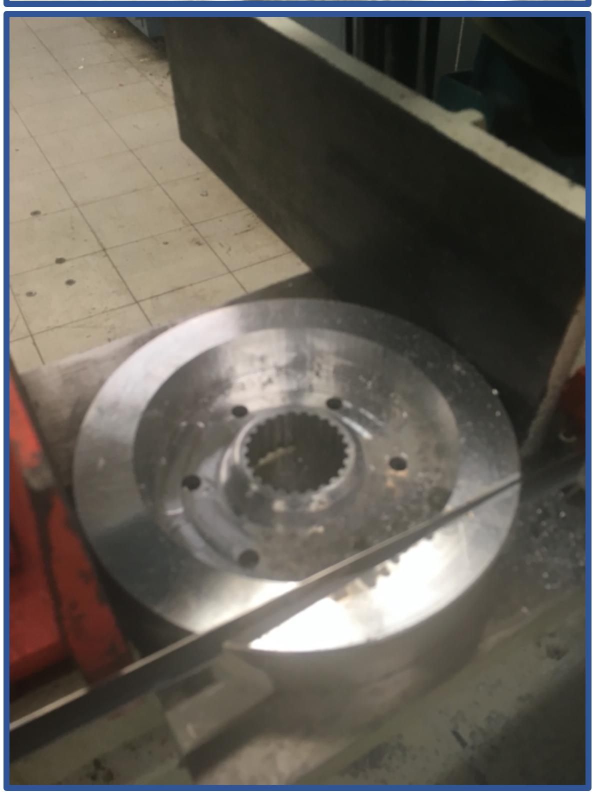


Static Displacement (mm) von Mises Yield Criterion (N/m2)



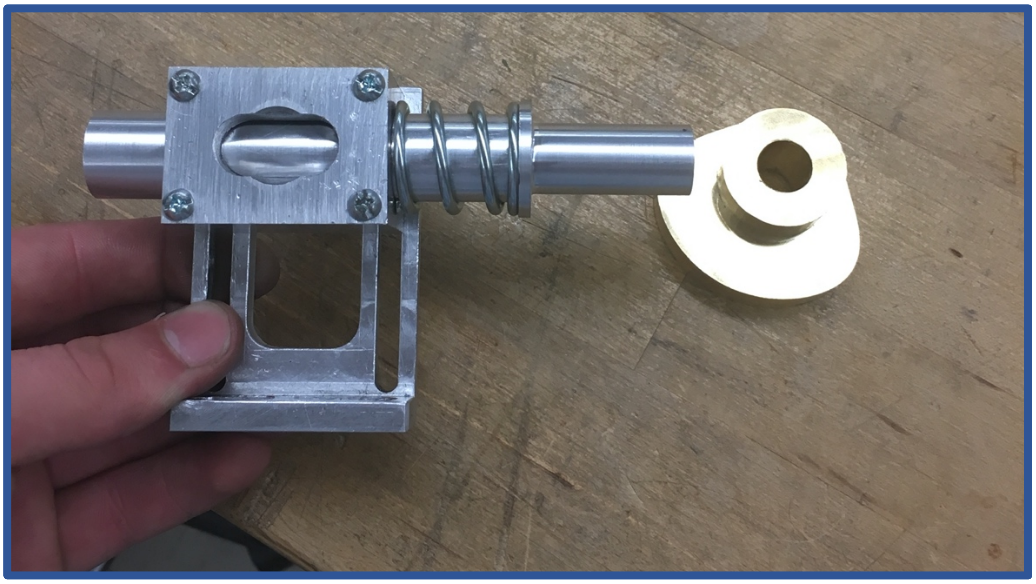
(c) Factor of Safety

Machining Examples

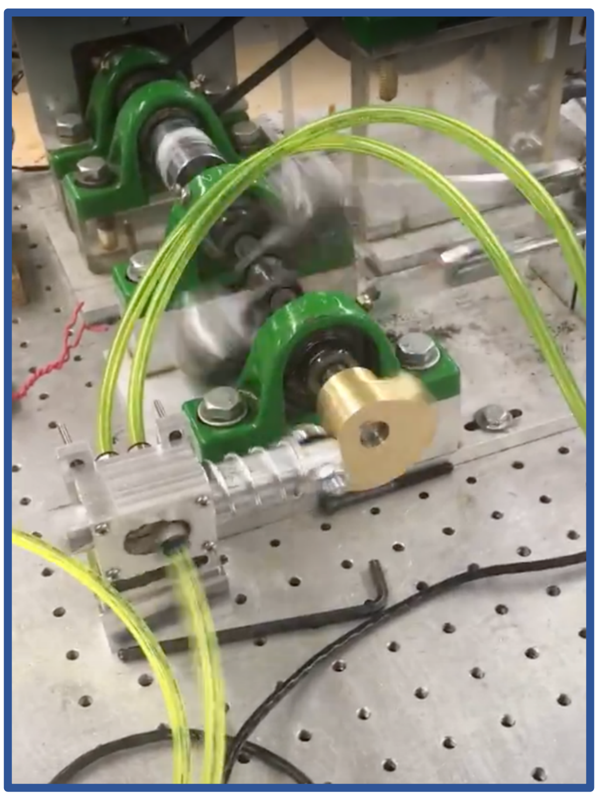





Design and Manufacture of Valve for Compressed Air Engine

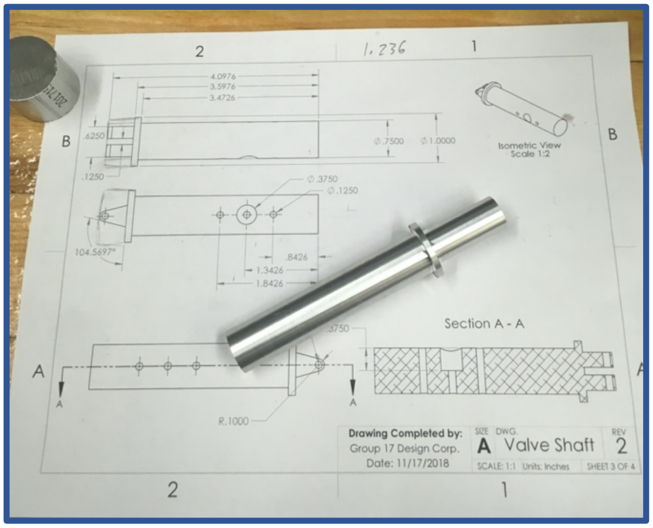
Objective: Design and manufacture a valve assembly to drive a compressed air powered piston in the machine shop. Utilized manual milling and lathing processes for shaft and housing, CNC milling for CAM

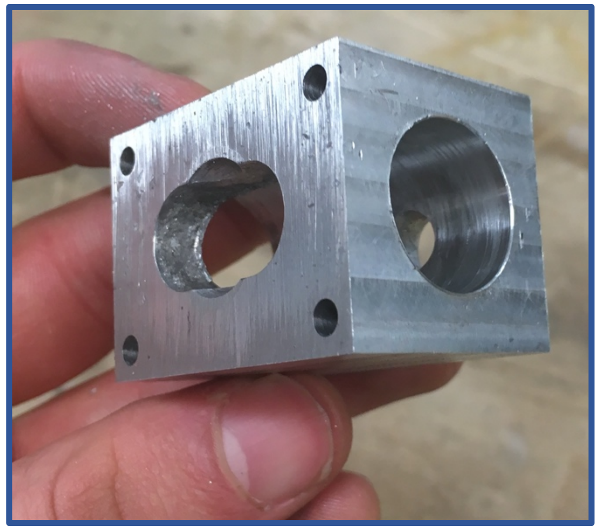


Manufactured Components



Assembly Driving Compressed Air 'Engine'





Manufacturing of Shaft and Housing

Weight Sensing Electric Skateboard

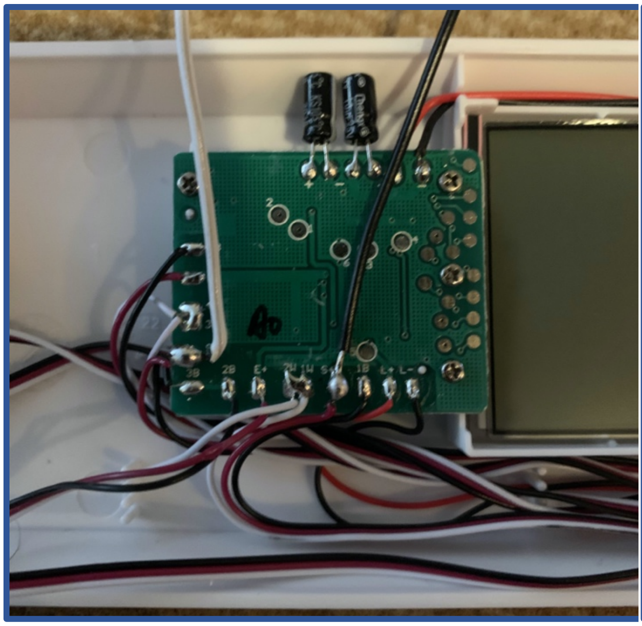
Objective: Design an electric skateboard that will be driven based off user weight distribution and foot placement instead of a traditional remote controller. (This is project is currently in progress).

I was inspired to make this because I did not want to get too tired commuting to places on a skateboard but holding a remote controller while using a traditional electric skateboard is an unnatural feeling.

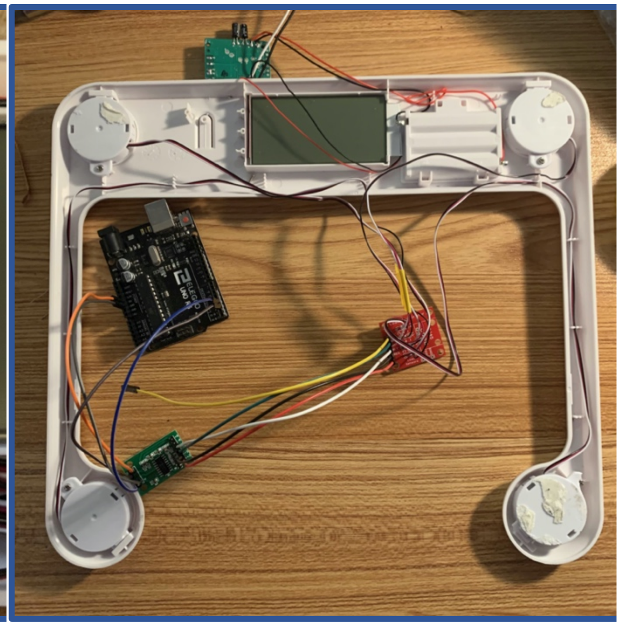
Also, commercial electric skateboards are too expensive.

The end goal is to design a modular system, meaning that all the electronic components could be removed easily and quickly so the skateboard can be used at a skate park for example.

Load cells are used to sense a user's weight distribution and foot position on the board. The data is analyzed with Arduino. The calculated speed is output from the Arduino to a speed controller with a PWM signal.



Load Cell wiring in scale



Load cells form scale wired to HX711 and data read by Arduino

Running a small DC motor by reading weight distribution across two scales. Determine motor rotation direction and speed with H-Bridge IC chip.

Testing/Calibration of Brushless DC Motor and speed controller through Joystick

Initial motor mounting on skateboard

Testing of scale/motor control system

CAD Design of Crank Mechanism

Objective: Model crank mechanism using Solidworks through visual and dimensional inspection