Drill Cart Alpha Design

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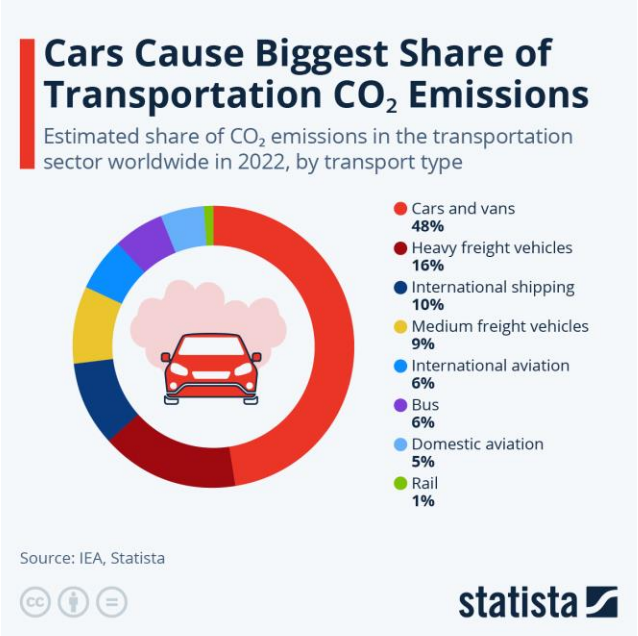
Project Overview

We designed, manufactured, assembled, and tested a cart powered by drill with a drivetrain and foot-based steering we designed. The purpose was to develop a mode of transportation that wasn't reliant on gas for fuel. Mechanical analysis was done using NX. After manufacturing, the cart was assembled, and tests were then done to determine of the initial requirements/specifications were meet.

Problem Statement

Impact for the customer that will directly benefit from a successful project.
"Broader impact" for those not currently directly involved.
Steppingstone to cleaner transportation, enhanced education, efficient energy use, raised awareness, etc.

- The American transportation system is heavily dependent on fossil fuels, which contribute to carbon emissions and consequently environmental degradation. Addressing this dependency is crucial for both the planet and its inhabitants. In terms of carbon emissions, the reduction of greenhouse gas has been particularly pivotal. This project aims to help fight the growing greenhouse gas problem by designing a car that is powered using an electrically powered drill. Inventions like this and other renewable technologies are a crucial step in reducing our carbon footprint. This approach not only supports current environmental priorities but also positions the project within the context of future advancements in transportation.



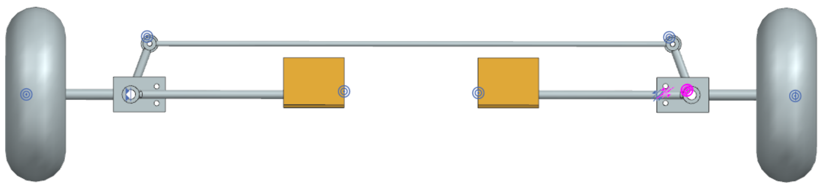
https://www.statista.com/chart/30890/estimated-share-of-co2-emissions-in-the-transportation-sector/

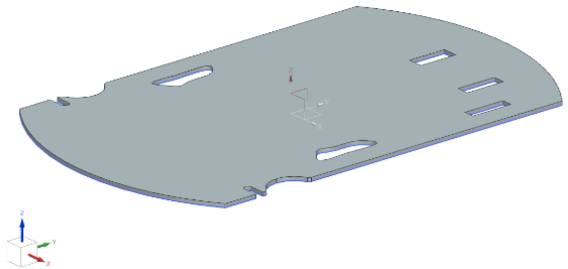
Deliverables, Requirements and Specifications

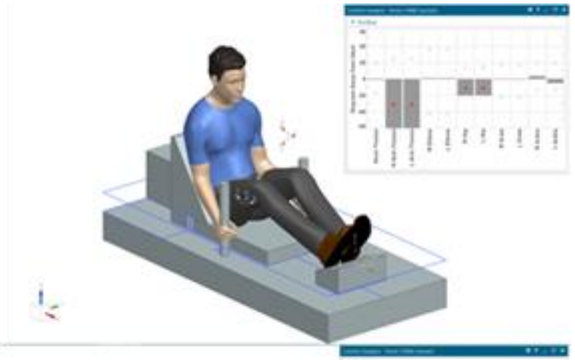
Deliverables:
- Prototype Drill Cart
- Safety Report
- Final Report with Test Data

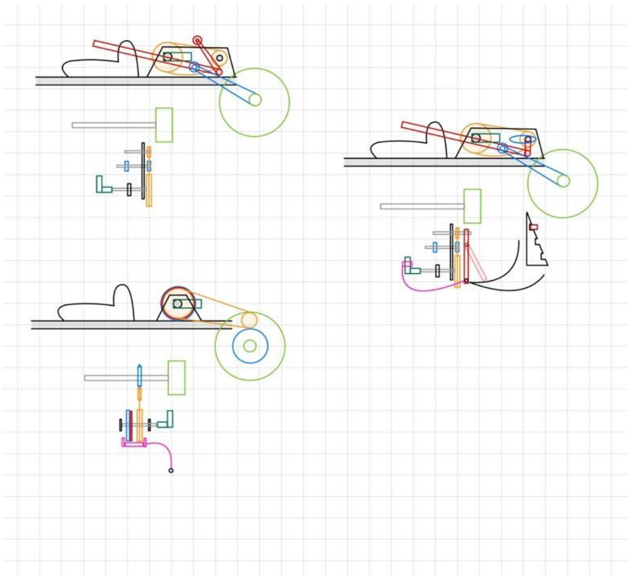
Requirements:
- The cart cannot have two wheels.
- The cart will be able to safely hold one driver, who will steer with their feet
- The accelerator, clutch, and brake will all be hand activated and reachable by the driver.
- The clutch will be designed in-house by the team.
- The frame will be made of plywood and must be cut on the Shop Bot.
- The cart will be operated with a single drill, mounted into the frame at the rear of the cart to transmit power to the wheels.
- The cart will have good safety precautions, such as a seatbelt, helmet, horn, and guarding.
- The cart will be able to complete multiple laps of the required course.
- Each cart will use the same tires and drill.
- The cart will use Ackerman steering angles.
- The drill will lock and stay on.

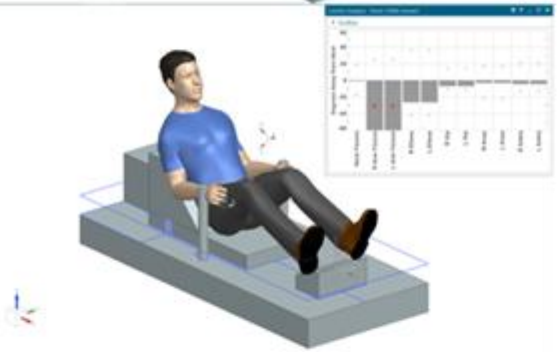
Specifications:
- The cart cannot have a breaking distance exceeding 15ft.
- The cart must have a turning radius smaller than 10ft.
- The difference in weight of the cart and driver between both teams will not exceed 5lbf. Sandbags shall be added to the cart of the lighter team to account for weight differences.
- The maximum speed of the cart cannot exceed 25 mph.
- 10 in. diameter wheels will be used by both teams.
- The same drill will be used between both teams.
- The plywood used will be 0.5 in in thickness.
- During the race, the driver must be switched every 2 laps.
- The bottom of the frame must be at least 8 in. above the ground.
- Cart must be less than 4 ft by 5 ft









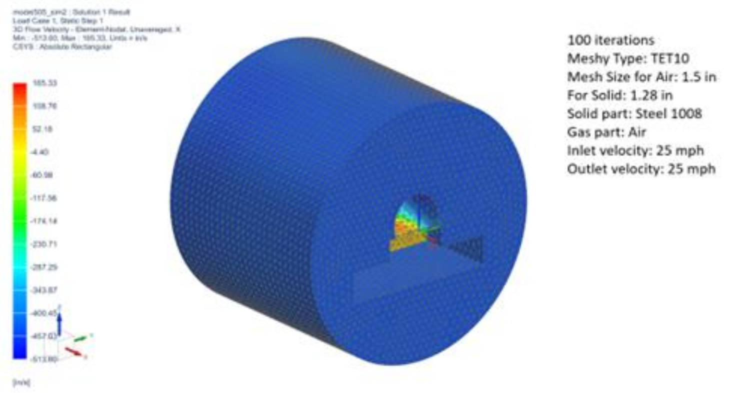


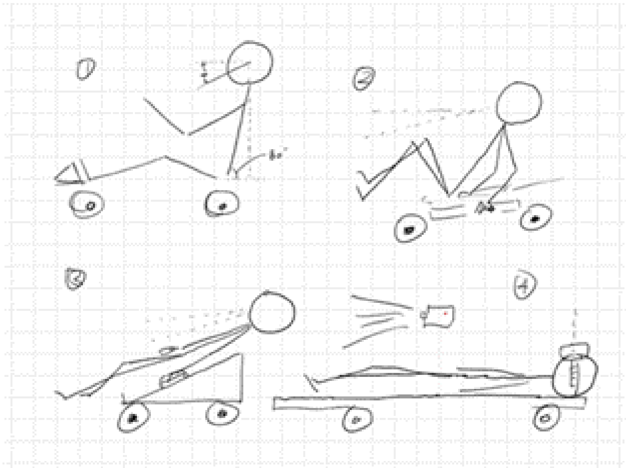
Current Project Status – Ergonomics

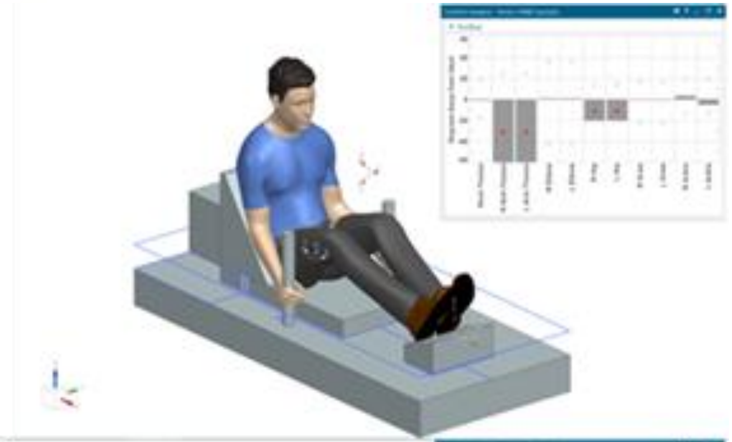
The flow analysis has been conducted to compare the aerodynamic profiles of different driving positions. The reclined position has shown the highest aerodynamic efficiency according to the result.

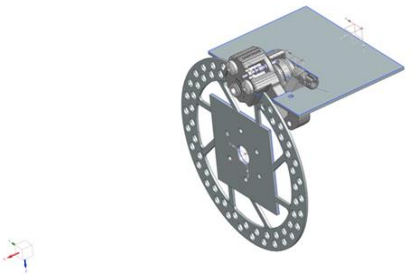
Three key components: Driver Seat, Brake System, Rear Axle Mount

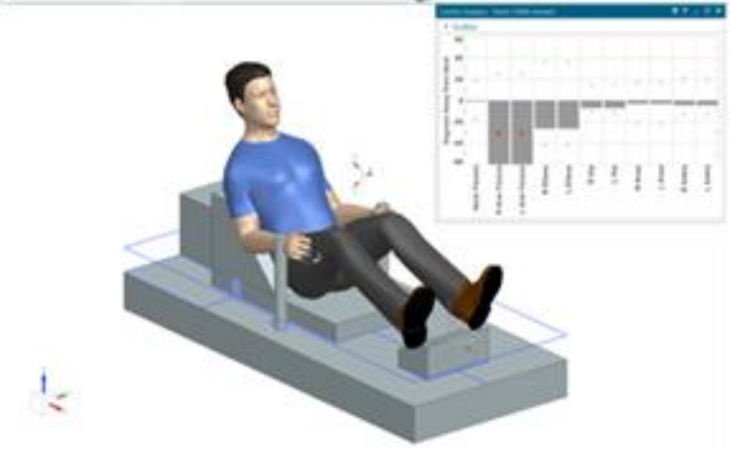
- The driver seat was cut out on the shop bot.
- The rear axle mount was constructed from bearings and wood.
- The brake system was built using a bike brake mounted on the rear axle shaft.

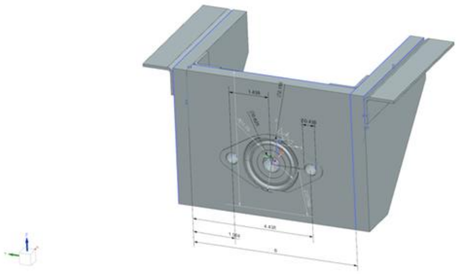








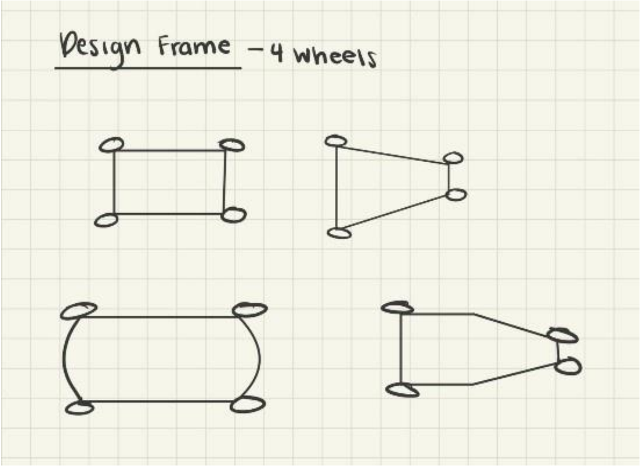


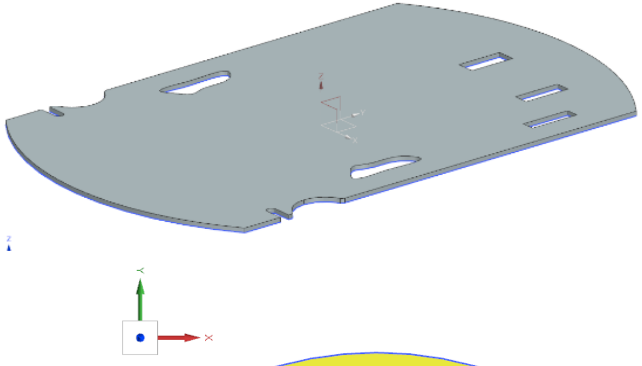


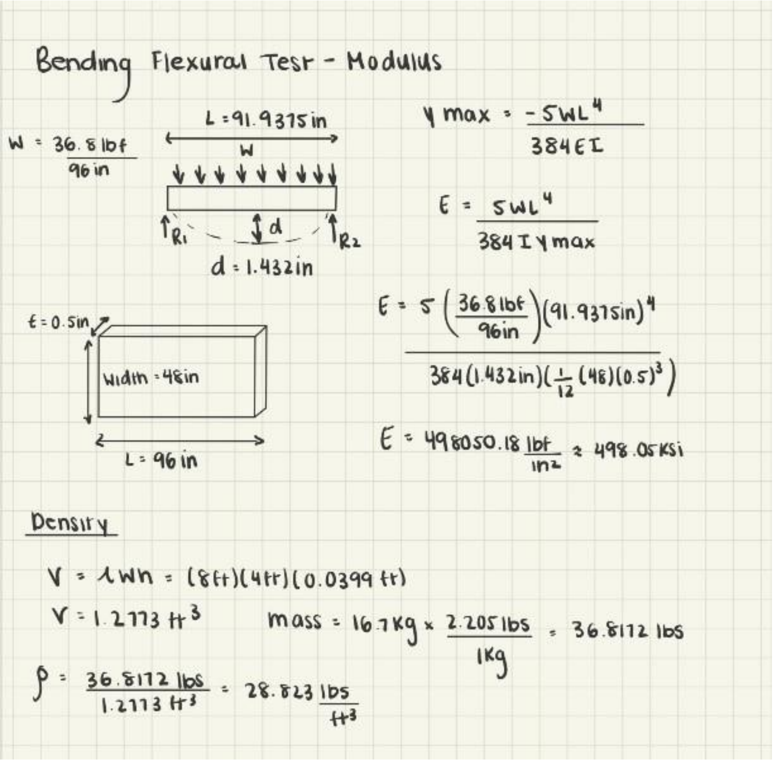
Current Project Status – Frame

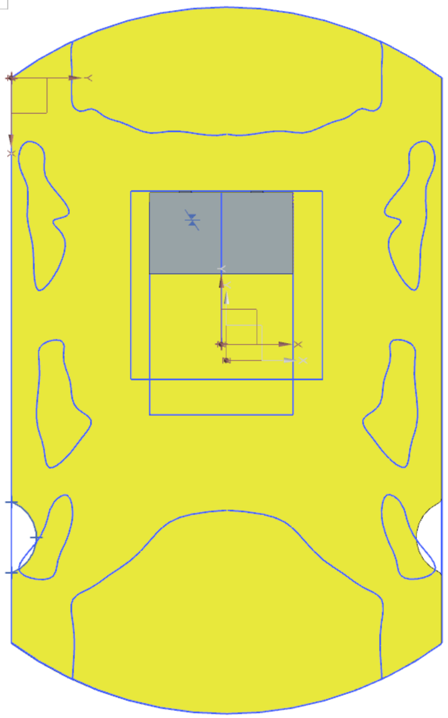
- Several frame concepts were considered, and the design chosen minimized displacement.
- Mechanical analysis was done to determine the properties of the plywood that was used for the frame, the seating, and the structure of the drive train.
- Finite element analysis was done of the frame to determine any portions that could be removed without causing any issues to the overall structure and displacement.
- The CAD of the frame was modeled using NX which consisted of implementing a manufacturing tool for the mill and drill.
- The STL file was loaded and connected to the Shopbot, and the 8ftx4ft piece of plywood was cut to frame.

New Dimensions/No optimization	Young's Modulus (psi)	Total Mass (lbfs^2/in)	Total Volume (in^3)	Density	Displacement (in)	Stiffness/Weight Ratio
1	498050.18	0.06133021	1.42E+03	4.32E-05	5.466	1.15E+10
2	498050.18	0.04115562	952.6222	4.32025E-05	8.229	11528283578
3	498050.18	0.06426433	1487.515	4.32025E-05	4.966	11528278806
4	498050.18	5.15E-02	1.19E+03	4.32E-05	5.879	1.15E+10



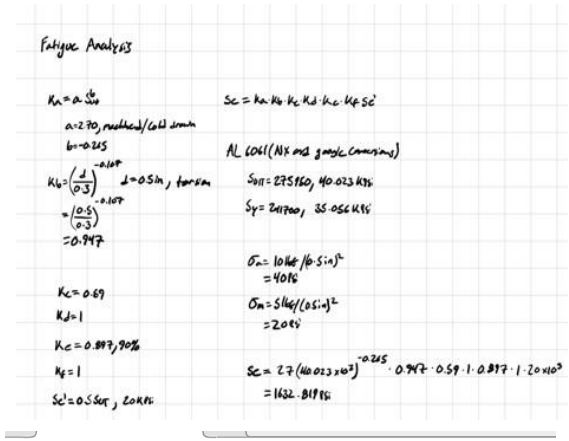


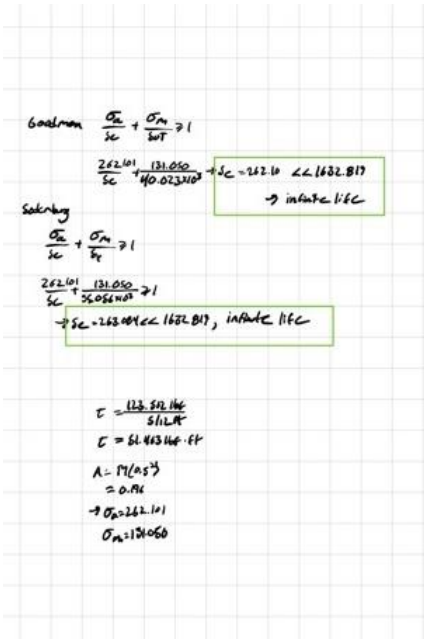




Current Project Status – Drive Train

- Three different concepts for the drive train were considered, and the design chosen was the simplest to implement
- Fatigue analysis was done on the drive train rods, which found that they more than strong enough.
- Calculations were done to determine the optimal sizing for the pulleys in the drive train to best utilize torque in our design.
- The Pulley system is constructed from a set of pulleys connected via a V belt, connected to milled aluminum rods via keys.
- This is held together with a wooden frame.
- The wheels are connected to the rear axle by a set of milled aluminum plates.



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omega_drill = 1300; %Revolutions per minute
omega_drill = omega_drill*2*pi/60; %rad/s

v_belt = omega_drill*drill_r; %in/s
omega_driver.main = v_belt/driver_r; %rad/s
omega_driver.second = omega_driver.main;%rad/s


v_belt_2 = omega_driver.second*5; %in/s

axel_r = 4; %in
omega_wheel = v_belt_2/axel_r;
V_max = omega_wheel*5(3600/(5280*12));
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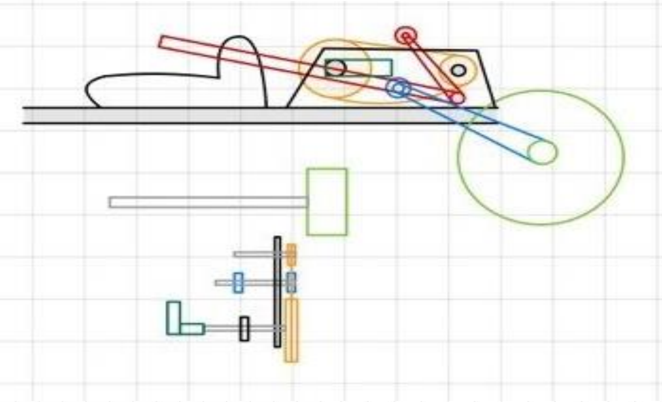
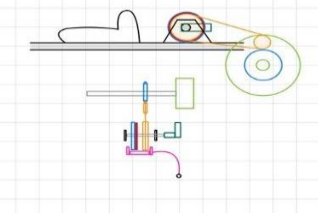
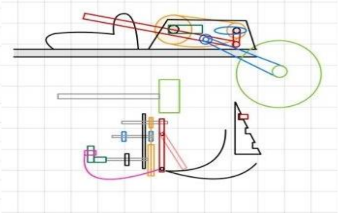
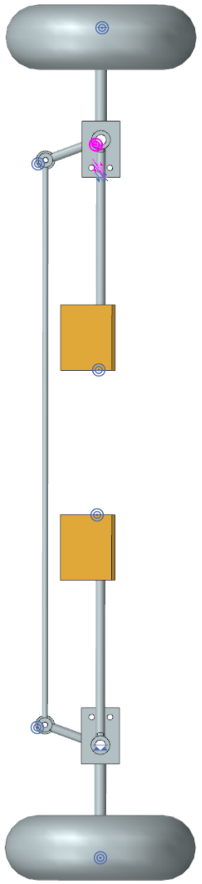


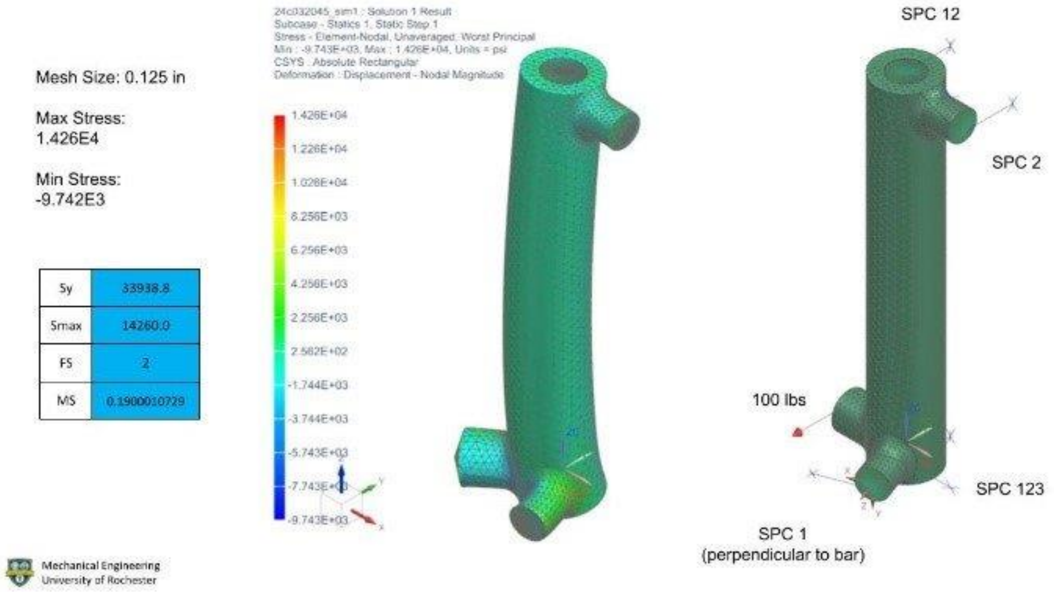




Current Project Status – Steering

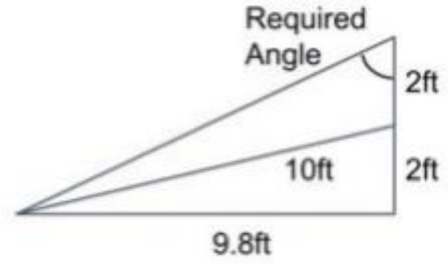
- Turning Radius calculations found that our design was sufficient for a smaller than ten-foot radius
- Analysis of other forms of foot steering confirmed that this is the most simple and effective
- NX analysis of steering knuckle optimized size
- Welded all portions of steering knuckle
- Machined endcap for Ackerman system
- Steering system installed and tested



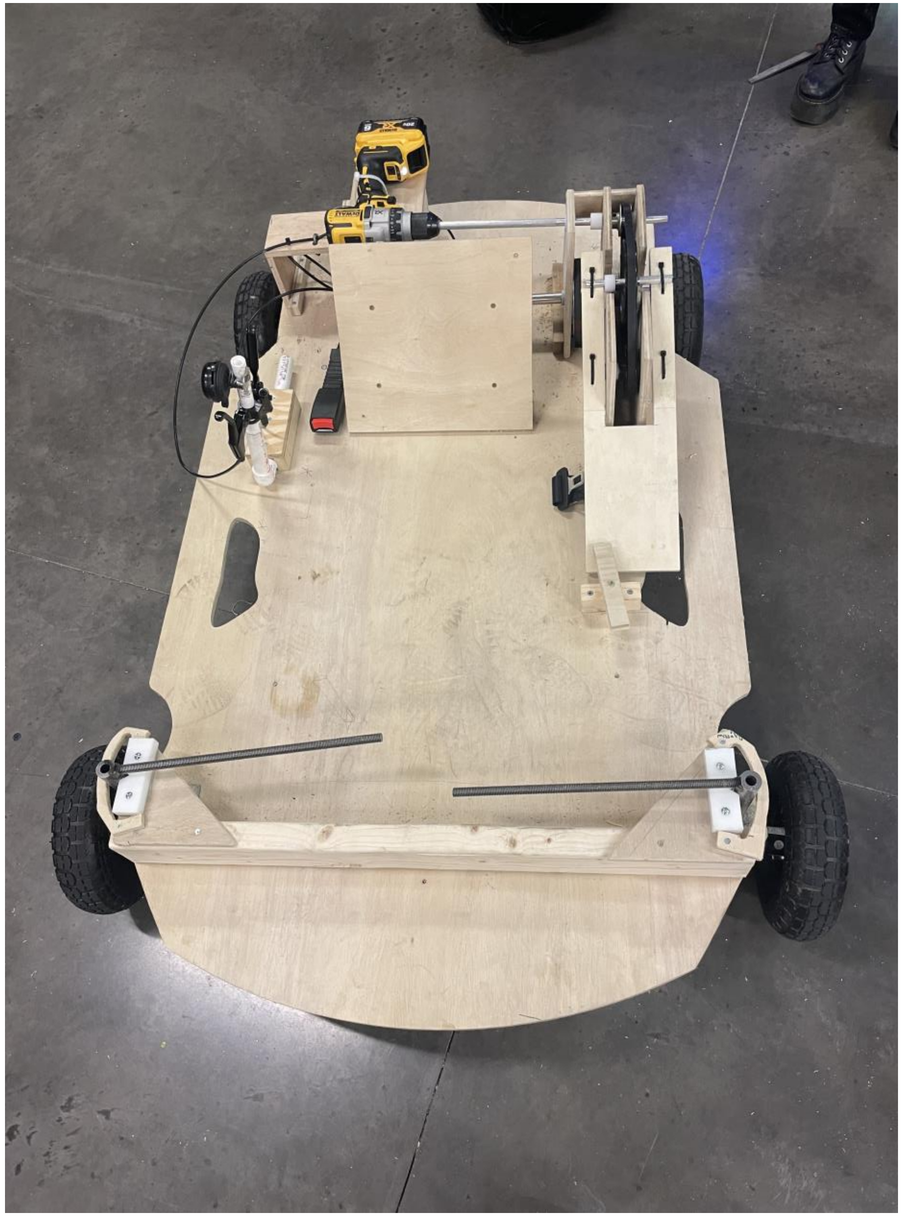


Required Angle =
Arctan(4/9.8) =
22.2 degrees

Required movement for 10ft turning radius.



Current Project Status – Final Product



Conclusions/Future Work

- Further NX optimization could have been performed on the frame and the steering knuckles.
- Weight could have been minimized or removed from some of the structural parts of the drivetrain.
- A more complex and cost-effective braking system could have been designed.
- Different types of materials could have been selected.
- More tolerance and fatigue analysis could be done with other subsystems
- A more efficient clutch system can be developed to make the cart go at faster speeds.

Acknowledgements

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