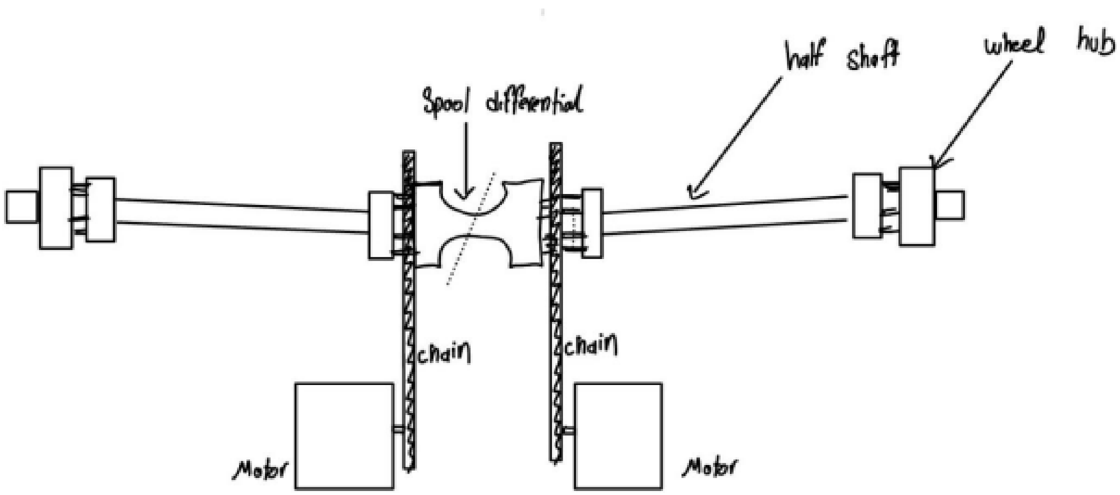
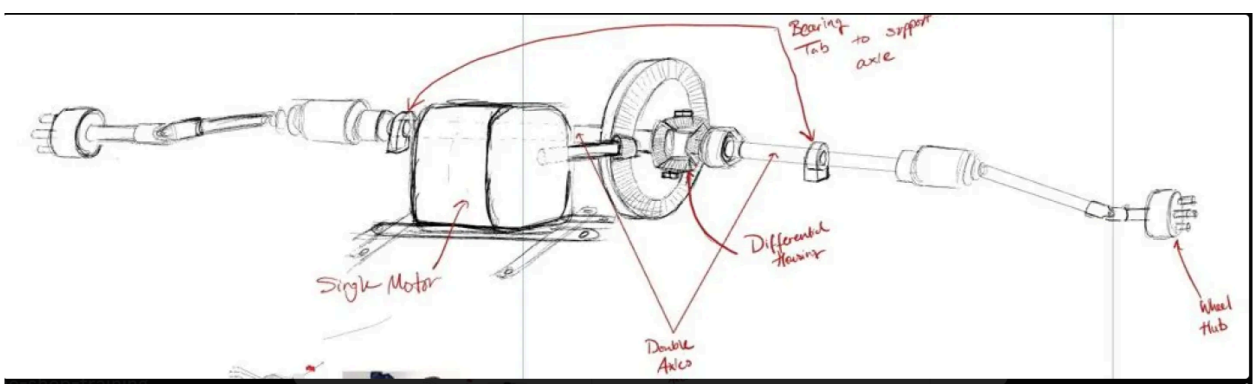
In my first semester I onboarded, learned about the planned EV3 design, researched CV axles, and participated in some other tasks. One of our main concerns during this time was the type of differential we would use. The first one is represented by the following drawing:

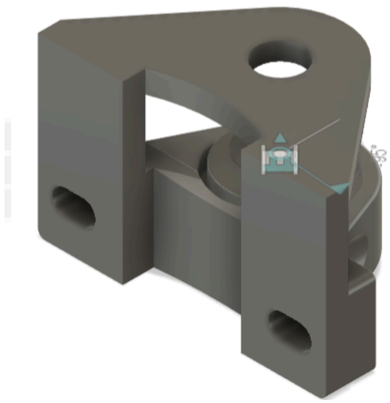
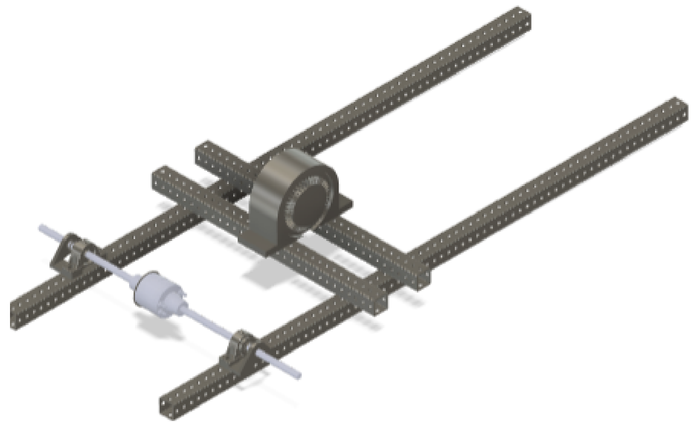


This design is much simpler as it is essentially a no differential design. This would allow for less points of failure as well as lower weight. However, this design would cause slippage when turning and make it more difficult for the driver compared to a design with a differential. When considering the energy savings, it would result in little difference due to the extra slipping even though the car weighs less. When we looked deeper into the rules however, we were able to settle on a design with a differential because without one, we would not meet the required turn radius to pass inspection. The design with a differential would resemble the following:



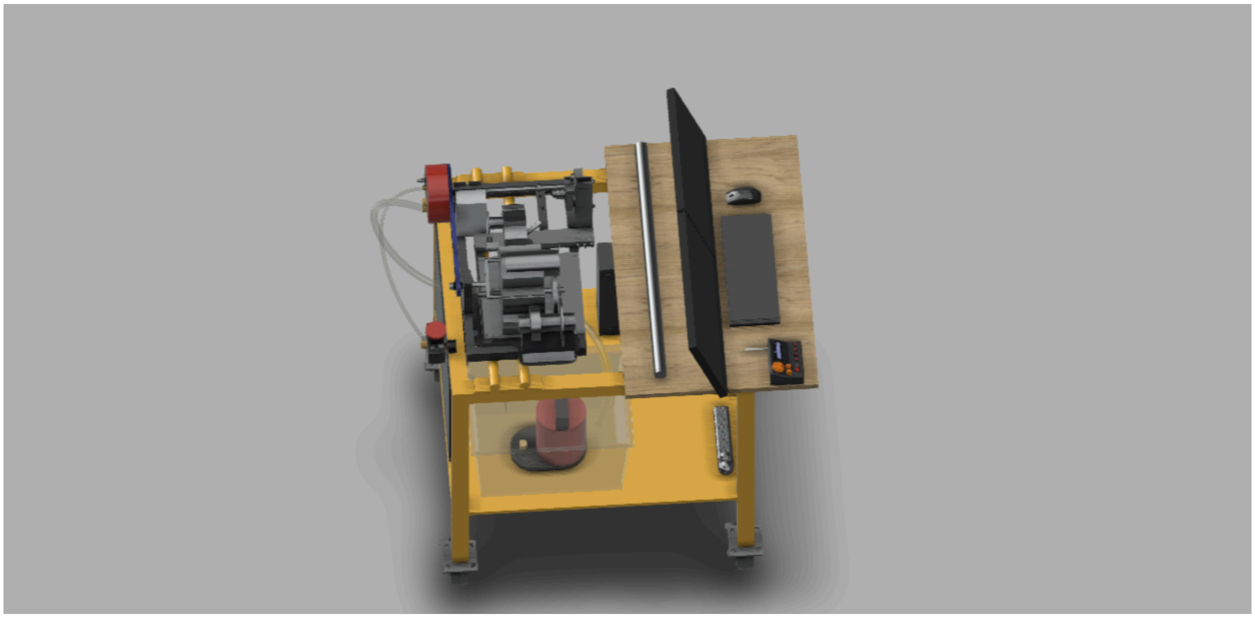
This initial design accounted for two motors. This was because in the previous years we were unable to get our cars running on the track due to the motors failing. However, down the line we stuck with one motor, as we saw the failure point did not occur in the actual motor but instead with the motor controllers, so our plan is to have multiple motor controllers made in case of any issues. Additionally during my first semester I worked on half shafts and CV axle research. After researching, we decided it was best to purchase an off the market half shaft and then remanufacture it through milling in order to adjust the length to our needs. One suitable half-shaft found on the market was the one below by Tesla (though this design was later replaced by the u joint design).

In my second semester, I got trained on the mill and did continual R&D on EV3. Additionally, I helped the team prepare for competition through working on repairs on EV2. In regards to my mill training, I enjoyed learning and was able to complete my part before the end of the semester. I plan to get CNC mill trained when that releases, and also get trained in waterjet to contribute towards the manufacturing process of the car. Our goal is to finish designing and manufacture the car before competition next year. One of our main focuses the first half of the semester was the design of our drivetrain and the different mounting points. I researched and found actual drivetrain and motors, where we actually purchased the motor this semester, and worked with a dyno to try to do preliminary tests. This path did not pan out in the long term, but was a good introductory exercise into learning how to evaluate motors. In addition to this, we made progress towards our decision making for how everything will be mounted on the chassis. A basic CAD model right now is as follows.

Though we rethought this design down the line, I will use it as a basis of explanation for our goals. We are attempting to find a way to mount the differential in such a way that it will not move left, right, up, down, or forward or back, and it will only allow the shaft to spin freely. To do so, we decided to implement a pillow block like structure with thrust bearings in order to better hold our part.

One major focus was working with the dyno, though it did not pan out due to external issues. It was lended to us from Eco, and we designed parts in order to fit our motor on it. The plan was to test the power output of our motor so we can see where our losses may come from and the optimal operating speed and such. Though the motor we currently have is just for testing, our actual motor will be of similar power output, but may have some different specs. For reference, I have attached the dyno CAD below. Though this process got scrapped, this stemmed the idea for us to build a jig so we could actually test our drivetrain assembly without having to wait for the body team to essentially design the whole monocoque and car.



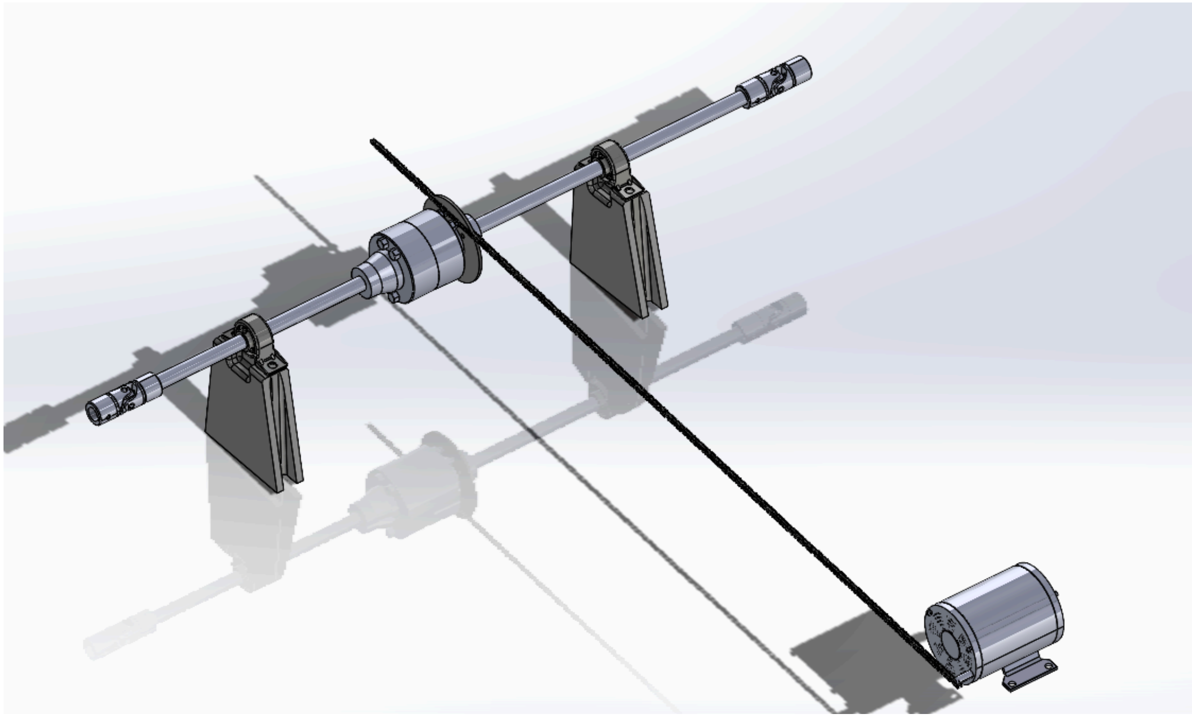
In the second half of the semester, we focused largely on the fixing of EV2, where we did have a successful outcome of the car passing technical inspection for the 2nd time as well as running a few laps on the track. In the repairs, I helped with the implementation of a sensor between the brakes and the lights. Initially, we were going to use a pressure sensor, but after ordering it, it was not proper. So, to deal with this, we decided to go with a switch we already had. I then helped ideate how the design would look like, and it was eventually designed and implemented, all things working out. In addition to this, I helped with the general repairs of the car making it ready for competition. I also helped design a safer mounting for the electrical systems. With the original mounting we had, it was somewhat unsafe and unstable. Therefore, we angle grinded a new bar in order to have a more secure mounting on the car.

Over the summer, I did some work in preparation for the upcoming semester. Our wheel spokes were essentially broken after the competition and we had to get this replaced. I did research and found replacement spokes that were put on the car as can be seen below.

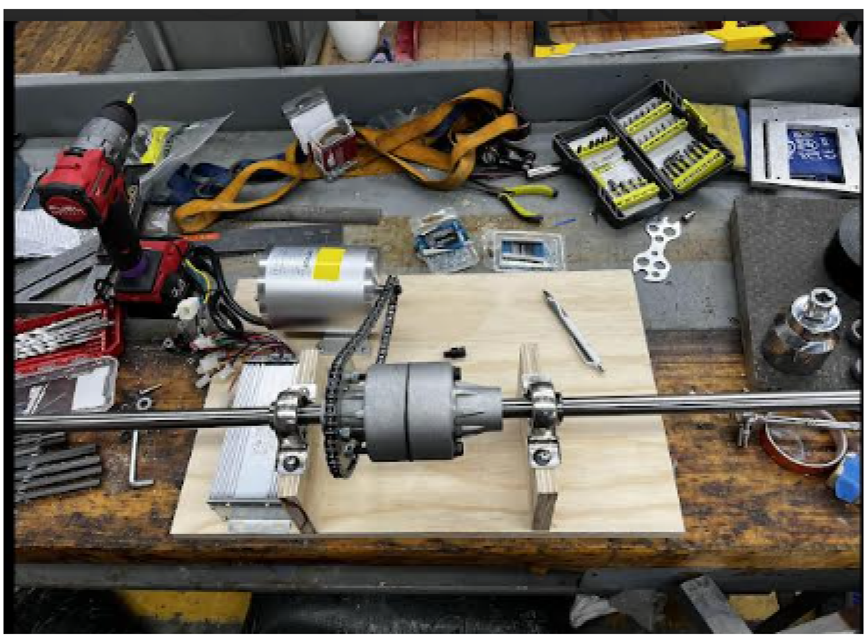
In my third and current semester, I focused heavily on design of components, in depth research, upkeep & upgrading of EV3 and I did some analysis work as well to validate my designs. Firstly, I will discuss the drivetrain assembly part of my work. When considering the design of the overall assembly, we first had to decide how to connect the shafts to the output (wheels). What I did was the research of this. Initially, we were planning to use CV axles, however, we decided these were too expensive and overcomplicated for our needs, and we settled on u joints. I focused on the research for these and what u joints to buy. The main restrictions I came down to was the material should be some sort of durable metal, such as steel, and the u joints should have keyed slots. This way, we can key our shafts using a mill and attach them properly. The overall configuration includes two shafts with two u joints on each side. Additionally, the u joints need to have an inner diameter of ¾ inch to match the current drivetrain shaft. When researching the u joints I came across a few examples as are depicted below. I ended up choosing the first u joint due to it meeting the requirements while being on the cheaper end. However, when I designed the drivetrain assembly I used the McMaster Carr component (the 4th u joint) for this design as it comes with an accurate CAD model.

Below, the picture of the drivetrain assembly can be seen. It is missing the extra component of having 2 u joints on each side, but that is just symmetrical on each side, and most of the information is communicated through this design. It includes the motor (at the bottom) connected to the sprocket using a chain. The sprocket is screwed into the differential. To do this, we need to modify the current sprocket we have in order to have holes for the screws in the correct areas. Then, this sprocket is mounted to the differential. The differential shaft has a pillow block attached on each side. This is then connected to a custom part which is made to mount to the monocoque of the EV3 body. Then, on either end of the shaft there is the u joint. This in general represents the current design state of the drivetrain portion, and in the future we will move onto the actual manufacturing of this. We currently have a drivetrain with sprocket and chain assembly on a wooden board so we can essentially have a jig to test our components and determine the optimal torque and power ratio the motor can supply to the wheels so we can design our car to go at the correct speed and assist the electrical and embedded subteams.



A current jig assembly made based on this is shown below.



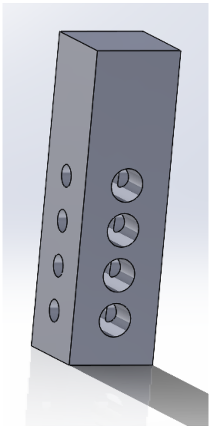
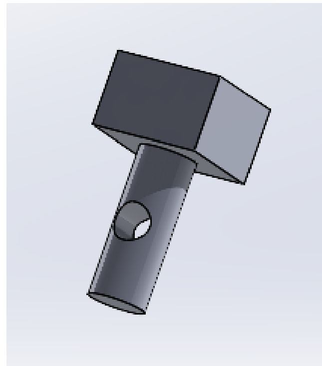
In addition to this ongoing drivetrain project, I also worked on the upkeep & upgrading of EV2. I did 3 main things this semester in terms of that: adding vinyl wrap, fixing the wheels, and designing a seatbelt mechanism.

For the vinyl wrap, I worked with a team to add blue and orange vinyl stripes on the car to revamp our look. To apply this, I learned the usage of a heat gun, squeegee, and also used some other materials such as a box knife.

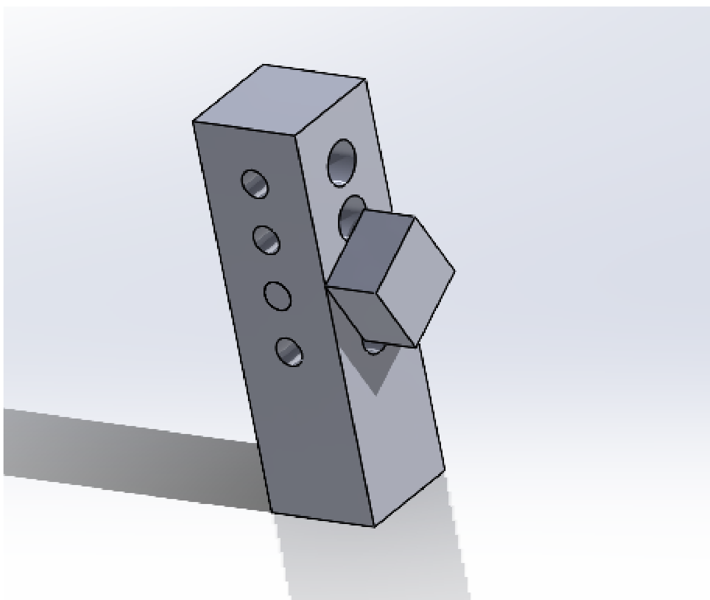
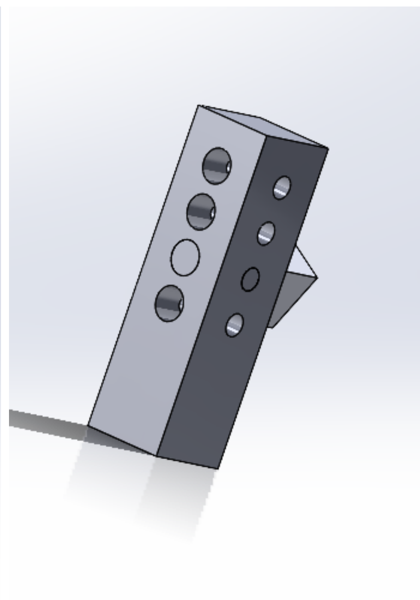
For the wheels, during competition last year, there were issues with the spokes and I essentially made sure the wheel was correctly trued and replaced the inner tube for one of the tires. Truing the wheels was an especially difficult task. In our current shop, we do not have a truing stand to work with. So instead, me and another member went to the local bike shop to try to get our wheels trued. However, we have a keyed adapter and our shaft size is not a good fit for any of the available ones, so this was also not an option. Therefore, I improvised through jacking up the car, mounting the wheels on the axle, and truing them on there. The axle itself has some inconsistencies so this led to imperfections. Additionally we had to do the truing by looking at where it leans out and in and not necessarily a fully scientific method. However, after much effort, I along with another member were able to true the wheels to an acceptable amount. Though the in and out undesired motion still exists, it is much less significant and our car should not be hindered by the wheels acting in this manner at this point.

Finally, the seatbelt mechanism is an ongoing project I am independently working on. During competition, we faced issues with the way the seatbelt over the driver and had to remount the seat belt so it covers the driver properly. However, we want to not face this issue this semester so I am working on a design where the seat belt mount height is adjustable so it is easy to change this during the competition based on our current and possible future drivers.

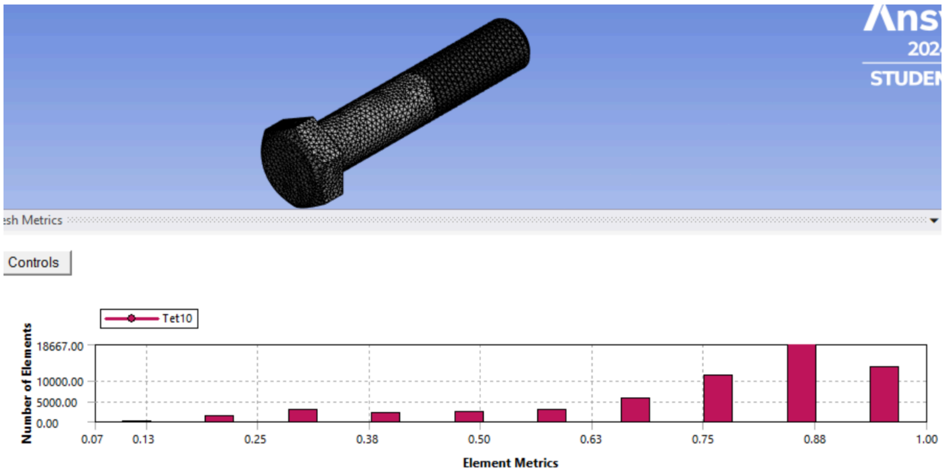
Below, there is the initial part design and assembly of my mechanism. On the left, there is the actual mount that will be on the body of the car. This initial design does not include the actual mounting mechanism, but that will most likely just include using the existing screw holes to mount it to the body. This design has multiple holes that are there for the seat belt holder to go into. This allows the holder to be adjustable. All the way to the right there is the seat belt holder, where the box represents where the top of the seat belt parts will go and this is currently abstracted. Finally in the middle, this is the force resistor which is inserted in the side of the block to resist forces pulling the seat belt holder directly out of the hole. All of these would be made from aluminum and machined using operations such as milling, lathing, and drilling.

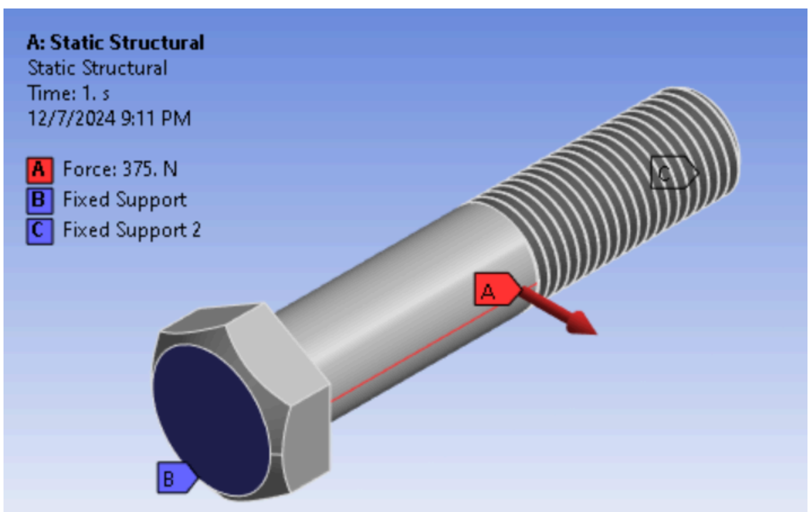
Some views of the assembly of the components can be seen below.

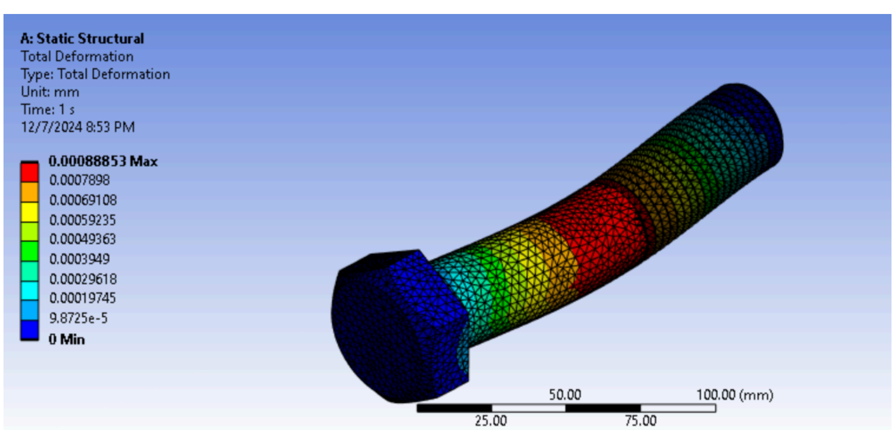
This design, if finalized, faces one main issue. That is, it would be unnecessarily heavy to install and could also possibly be uncomfortable for the driver based on the placement. The improvement idea would then be to use screws and their shear stress capabilities to prevent movement of the holder without the user explicitly doing so. Assuming the driver will weigh around 50 kg, I also conducted FEA analysis to confirm the screw design would work. The screw must be equivalent in length to the Force Holder, which currently is 6.25 inches, though is subject to change in the future. Note that this means that the block holes will ideally be tapped at the end so the screw can fix itself. Additionally, I went for a FS of 1.5. Assuming the car accelerates from 15 to 0 in 3 seconds the force computed on the nail is 375 N max. The screw is made from stainless steel. First I meshed the nail and checked the quality to get what’s below.



The element quality based on the body sizing I did is good enough to move onto the next step. I then applied the fixed points and the force in order to determine the deformation of the nail.



Finally, the total max deformation of the nail is .8 um, which shows its more than strong enough to resist the jerk forces of the driver.



Based on this analysis, I can now continue to future design iterations in the coming semester. I will attempt to reduce the thickness of the block, as well as make threaded holes for the screw. For total installation this should simply be a case of adding a plate to the back that can be screwed into the monocoque. An additional consideration for the future may be to reduce the block width, so the screw can stick out and simply secure it with a hex nut.

To summarize, in the past few semesters, I joined the mechanical subteam of EV Concept and was focused on the upkeep and upgrading of the previous generation car as well as the drivetrain design of the next generation car. At the current moment, designs are being finalized, and with my manufacturing skills such as milling that I have been trained on, next semester, I will help with the actual fabrication of the vehicle.