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Design and Fabrication of Rear Suspension and Drivetrain for Union College's SAE Baja Car

Nicholas W. Oren

Union College - Schenectady, NY

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Design and Fabrication of Rear Suspension and Drivetrain for Union College's SAE Baja Car

Nick Oren

Advisor: Professor Tchako

Senior Project

March 16, 2011

Executive Summary:

My senior project is to design and fabricate the rear suspension and drivetrain for Union College's SAE Baja car. This project started with the determination of the optimum style of suspension and drivetrain for use on the vehicle. I worked with a company to obtain a custom-built transmission, and I successfully designed the drivetrain to use this transmission. I also designed the frame of the Baja car required to mount these elements. Finally, I designed the rear suspension of the car.

The drivetrain design incorporates a 5-speed sequential transmission with a reverse. This transmission is driven by a centrifugal clutch which prevents the engine from stalling. The drivetrain is capable of a top speed of 27mph in fifth gear and puts out a maximum of 440 ft-lbs in first gear. The suspension is a semi-trailing arm design that is fully independent and allows twelve inches of travel for each wheel.

At this point the framing and drivetrain are fabricated. Next term I will continue to work with the machine shop to fabricate the suspension components needed to complete the project.

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Background:

SAE Baja is a collegiate design series competition. It is designed to simulate a true engineering design project that students will be faced with in the real world. Teams of college students design and build off-road vehicles that endure a three-day event specifically aimed at pushing the cars to their limits.

The cars built for this competition are required to use a 10 horse power Briggs and Stratton engine. No modifications are allowed to the engine. This rule is to ensure that all teams are working with the same power, and that the team that can achieve the most with this equal power wins.

Another aspect to the Baja design series is that some of the regional competitions require the cars to be amphibious. The competition being attended by Union's team this year does not have a water event.

The competitions are a three-day event with each day focusing on a specific aspect of the car. The first day is called the static events day. The most grueling part of this day is the technical inspection. In this rigorous examination, the entire car is inspected from top to bottom to ensure that every bolt, weld, dimension and system is compliant with the rules. This day also includes a design presentation and a sales pitch. Cost reports and design reports, submitted at an earlier date, are returned to the teams at this point as well.

The second day is called the dynamic events day. During this section of the competition, the cars are subjected to numerous mini-events. In the past, this section has included acceleration tests, land and maneuverability tests, suspension and traction tests, rock crawls, hill climbs, tractor pulls, mud pits, and water maneuverability courses.

The third day is the main event. It consists of a 4-hour endurance race. In this race, teams are given 4 hours to complete as many laps as they can around a 2-mile track. This track is designed to break the cars. Previous endurance courses have included logs that the cars must drive over, long and steep stair cases that the cars have to climb up and down, mud pits, drop offs, jumps, and anything else the event organizers can think of that will break or get them stuck. Figure 1 shows pictures of past endurance races.



Figure 1: Past Endurance Races

Problem Definition:

For my senior project I focused on designing the rear suspension and drivetrain for Union's Baja car, which includes everything behind the firewall. An example of what my project includes is shown in Figure 2.



Figure 2: Picture of drivetrain, rear suspension, and rear framing

To complete my project I will design and fabricate everything needed to transfer power from the engine to the wheels and hold the rear wheels in place. This part includes the rear section of the framing used to hold the drivetrain and suspension components in place; such as the engine, transmission, suspension links, and CV axle.

The final design must meet certain criteria. First and foremost my design must be strong enough to withstand the testing and competition without breaking, and yet also be lightweight. The final design also needs to incorporate components that our team already has in order to save money because of our team's limited budget. Additionally, the final design should be easily retrofitted to allow the addition of flotation devices to enable the car to compete in future amphibious events. The drivetrain must be capable of producing large amounts of torque at low speeds, as well as be able to propel the car to high speeds. The suspension design must be adjustable, lightweight, strong, and keep tire contact patch to a maximum during suspension travel.

Past Designs:

In the past, Union College's team has done very well in the competition. However, last year Union's team failed to complete a car in time to compete.

Drive Train

Figure 3 shows the drivetrain that Union's team used for the 2007-2009 car.

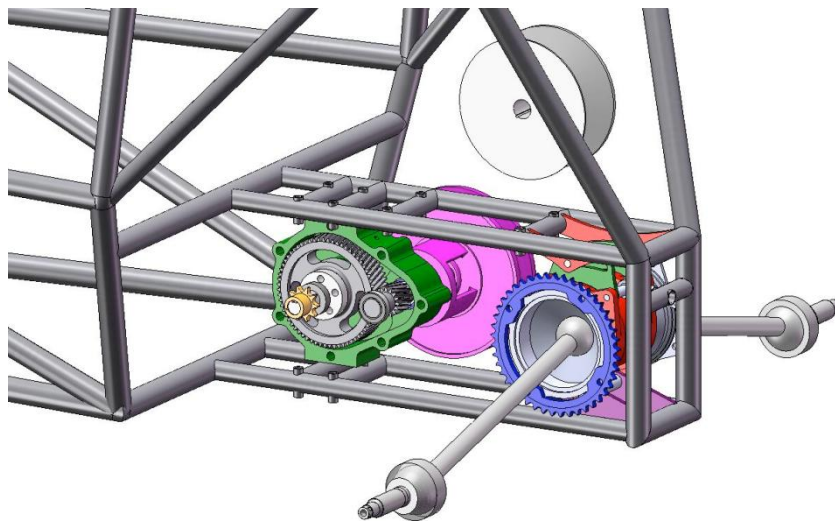


Figure 3: Past Union College Drivetrain

This drivetrain uses a belt driven continuously variable transmission (CVT) as its clutch and to vary the gear ratio based on the speeds of the wheels and engine. This system uses two pulleys that can change their effective diameter using centrifugal force. This system is commonly found on snowmobiles. From the CVT, a 4:1 reduction gearbox is used to increase the torque output. Finally a chain is run from the gearbox to the CV axle. This system requires the engine to be mounted “backwards.” This type of mount means that the exhaust is facing the firewall, which is not allowed, and must be re-routed out the back of the car. The added loop on the exhaust lowers the performance of the engine. Also, the throttle must be pulled backwards which was problematic in that it required the throttle cable to make a sharp bend which would then kink the throttle cable.

This drivetrain also had a few flaws. First is the efficiency of the system. An absolutely perfectly tuned and aligned CVT has an efficiency between 90% and 92%. Due to testing regulations imposed by Union, the team is only permitted to test a couple times a year and there is no time during test runs to tune the CVT. The true efficiency of the CVT has been estimated to be around 80%. The CVT efficiency combined with the efficiency of the gear box and the chain results in a total system efficiency of around 70%. This system efficiency is unacceptable.

Another flaw is due to the nature of the CVT. The CVT uses a belt to transfer power from the driving pulley to the driven pulley. When this belt gets wet from mud, or during water events, it slips. In the past, the event organizers have put a hill climb directly after exiting a water section in the endurance race. Teams with CVTs end up sitting at the bottom of the hill slipping their clutch until the belt heats up sufficiently to dry up the CVT and engage. Also, with the CVT the driver cannot control the gear that the system is in. This lack of control has made the system perform unpredictably, such as staying in a low gear when it should shift up to increase speed.

A final flaw with this drivetrain is the fact that it doesn't contain a reverse. After three years of Baja experience I cannot emphasize enough the importance of a reverse. It allows cars to make multiple point turns and most importantly, to get unstuck without losing points.

Suspension

Figure 4 shows a picture of the rear suspension used by the 2007-2009 Baja car.

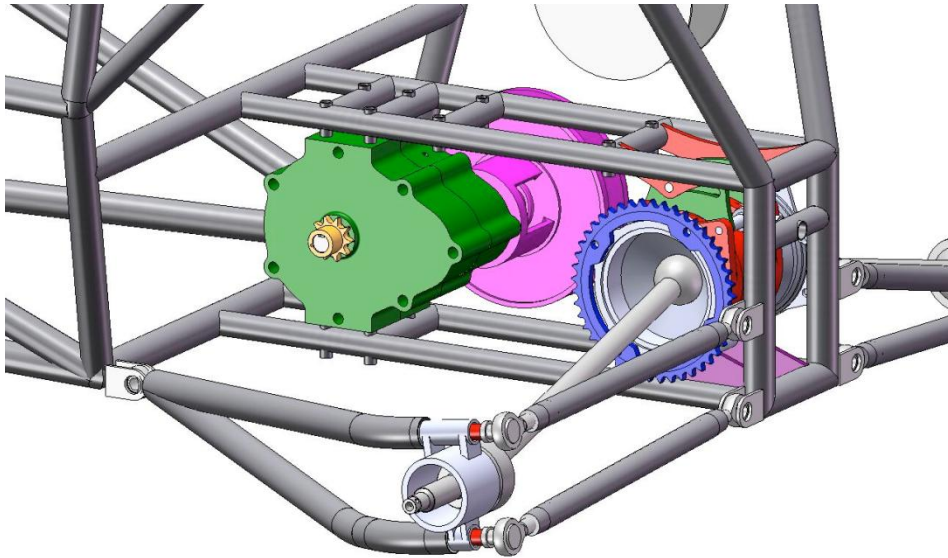


Figure 4: Past Rear Suspension

This suspension system is called a semi-trailing arm. It performed very well in the events in which it was used. If Union's team is to continue to use this suspension, significant modification needs to be done to prevent the loss of design points from reusing a design.

Design Options:

Drivetrain

I started looking into what other teams were using for their drivetrains at the competition last spring. Many teams still used the CVT system. All of the teams that use CVTs incorporate another gearbox or transmission in order to reduce the speed. The best CVT design that I saw used a gearbox out of a Polaris Magnum ATV. This gearbox had a high (3:1), low(7:1), neutral, and a reverse. It was significantly smaller than most other gearboxes that accomplished the same task. I looked into this option, but didn't like it due to the fact that it still used the CVT which has the many problems previously discussed. Also, with such a wide gap between the high range and the low range, neither range could be optimized as the primary drive.

The other popular drivetrain used is a sequential transmission. These transmissions have between four and six gears and are commonly found on ATVs, dirt bikes, and motorcycles. The problem with these transmissions is that they are almost always built directly into the engine block, as seen in Figure 5.

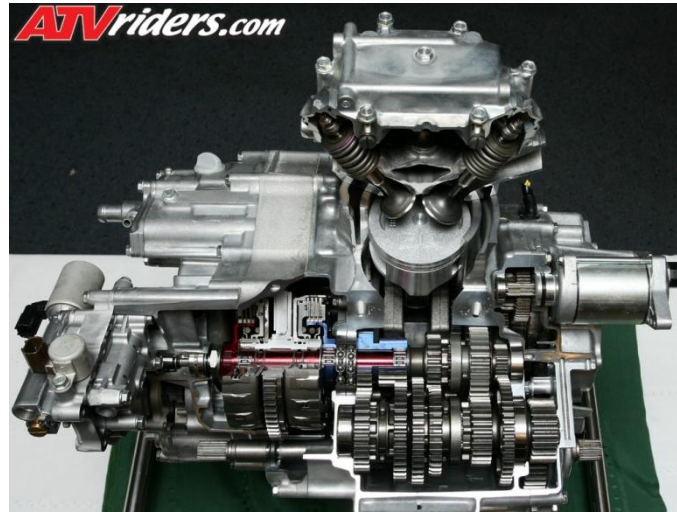


Figure 5: Sequential ATV Transmission Built Into Engine Block

Many teams had success either modifying the engine block to use a dummy crankshaft, or fabricating a custom housing for the transmission. However, it seemed that for every team that successfully modified the transmission, there were two teams that tried and failed. Another problem with using an existing transmission is that it is unknown what loadings the transmission was designed for. One team that I know of last year used a six speed sequential transmission from a dirt bike. However, this transmission was only designed to handle the weight of a dirt bike and failed during the endurance race due to the fact that it was now pushing around a 700lb car. Teams that have used this drivetrain have generally used the wet clutches that are almost always incorporated into the engine block with the transmission.

Suspension

I looked into four suspension options to use in my design. The first was the semi-trailing arm style discussed in the past design section. This system was good, but would need to be changed to avoid losing design points. Also, if used this system would need to be modified to accommodate a different drivetrain.

The second option I looked into was a full trailing arm style suspension. This system can be seen in Figure 2. As seen in Figure 2, the suspension arms pivot along an axis mounted on the frame of the car perpendicular to the direction of travel and parallel to the ground. After looking into this suspension I determined that this style had no adjustment, very little travel, and was not an ideal option.

The third option I looked into was a swing arm style as seen in Figure 6.



Figure 6: Swing Arm Style Suspension

Of all the options this suspension would be the easiest to design, but the suspension would not be an independent rear suspension. The design would have to include a solid rear axle which would make for a rough ride. Also, it would not be able to go over obstacles as well as the other two options due to the fact that it is not an independent system. An advantage of this type of suspension is that it would be easy to add a differential. Using a differential would produce a smaller turning radius.

The fourth option that I found that could be used is an A-arm, or double wishbone, type independent suspension as seen in Figure 7.

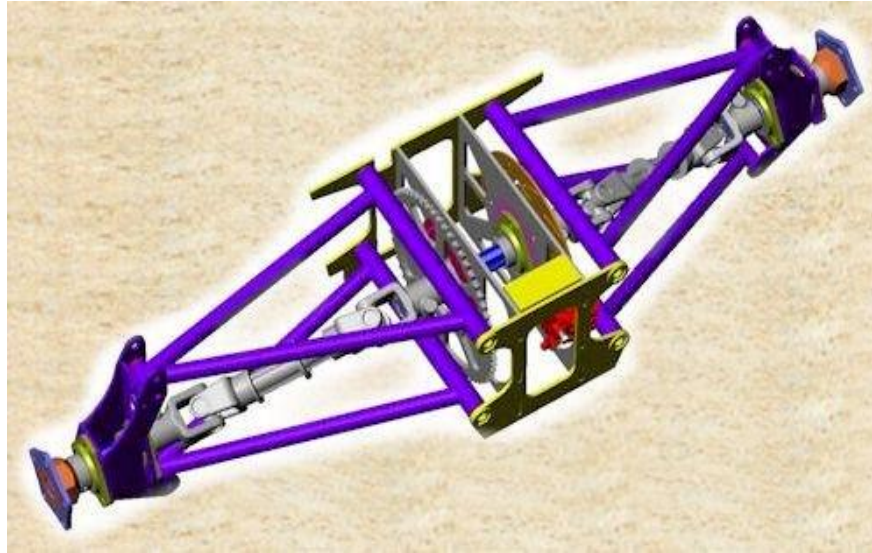


Figure 7: Double A-arm Suspension

The Union Baja team has used this style in the front suspension for many years without any problems. This suspension could be made lighter and more compact than the semi trailing arm; however it would not be as strong. A large advantage of this suspension is that it can be made to be highly adjustable.

Design Methodology

To complete my senior project I started with the drivetrain design. The drivetrain was the driving force behind my project and I knew that it would be the most important aspect of the project. After finishing the design of the drivetrain I went on to design the rear suspension of the car. I initially choose to design a double A-arm style suspension. I designed this suspension in its entirety but when I went to add the suspension to the assembly with the drivetrain, I realized it would not work; rather it caused multiple points of interference. This problem led me to the total redesign of the rear suspension and the use of a semi-trailing arm design. While designing the final suspension I began working with the machine shop to fabricate the framing needed for the drivetrain as well as fabricating the drivetrain components. By multi-tasking these jobs, I was able to fully fabricate both the framing and drivetrain by the end of winter term, as well as finishing the design of the rear suspension which will be fabricated next term.

Drivetrain Final Design:

I determined that in order to increase the efficiency of the system, the CVT system that has been used by Union's team for many years needed to be eliminated. At the most recent competition last spring, it was clear that the teams that made use of sequential transmissions dominated the track. A sequential transmission would be much more efficient than a CVT and would allow full control of the gear selection. However, finding one that was a stand-alone unit, not built into an engine block, was very difficult. Also I determined that having a reverse should be a priority.

After seeing how limited the choices were for transmissions, I determined that the drivetrain and suspension should be designed around the transmission. Through my research I learned that certain Harley Davidson motorcycles have transmissions that are independent from the engine block. After more research I came across a company, Baker Drivetrains, which builds aftermarket transmissions for Harleys, as well as custom built Choppers. I contacted a representative of the company, Scott Lerg, in mid-September. Mr. Lerg was very eager to work with me on my project and agreed to sponsor our team by selling me a transmission at cost. For the next few weeks I worked with Mr. Lerg to create the ideal transmission for the drivetrain. The transmission that he suggested was their DD5 with their reverse package. This transmission included 5 forward speeds, one reverse, and weighed just over 30lb wet (with oil). As part of the design process I was able to select the gear ratio of each gear from a few different options. In order to accomplish this task I created Table 1, and used it to evaluate the performance of the drivetrain. In order to create Table 1, I used the engine torque graph shown in Figure 8.

Gear	Ratio	Min Speed (mph)	Max Speed (mph)	Max Torque (F-lb)	At Velocity (mph)	Thrust [lbs]	Force[N]	Acceleration [m/s^2]
1	3.24	3.88	8.18	437.77	5.60	420	1869.391	6.2
2	2.21	5.68	12.00	298.60	8.21	287	1275.109	4.3
3	1.6	7.85	16.57	216.18	11.34	208	923.1561	3.1
4	1.23	10.21	21.56	166.19	14.75	160	709.6762	2.4
5	1	12.56	26.52	135.11	18.14	130	576.9726	1.9
R	2.82	4.45	9.40	381.02	6.43	366	1627.063	5.4

External Gearing	10.66
Tire Diameter [in]	25
Max Engine RPM	3800
Min Engine RPM	1800
Max Torque RPM	2600

Transmission Eff	0.96
Chain and Sprocket Effiecy 1	0.98
Chain and Sprocket Effiecy 2	0.98
Total Eff	0.921984
Mass [kg]	300

Table 1: Drivetrain performance evaluation

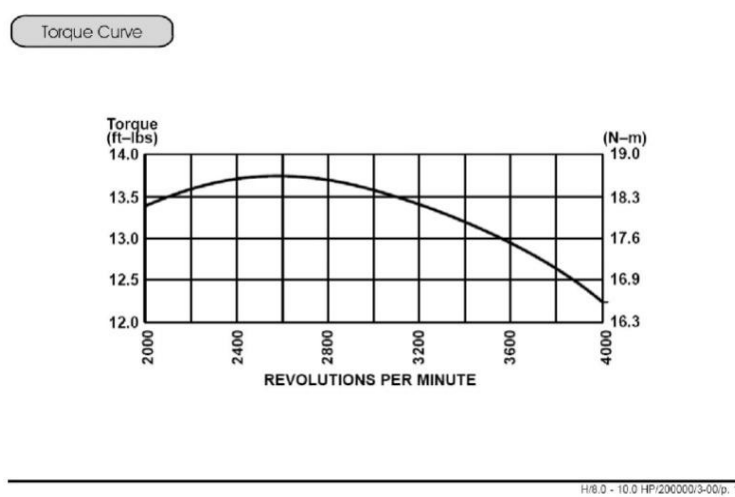


Figure 8: Engine torque curve

Table 1 shows the maximum and minimum speeds that the car can be going in each gear. It also uses the torque curve to find the maximum amount of torque being transferred to the wheels, the forward thrust, and the acceleration in each gear. The efficiency of the drivetrain system is included in these calculations. I worked with Mr. Lerg to estimate the efficiency of the transmission and did some research to estimate the efficiency of each chain and sprocket set. I determined that the ratios shown in Table 1 were the optimum ratios to be used in the transmission. In order to use this transmission, an external gear ratio of 10.7 will need to be implemented. This reduction will be made up from the chain and sprocket sets that connect the clutch to the transmission and the transmission to the engine, discussed later in this paper. After the transmission was finalized, Baker Drivetrains took four weeks to build and ship it. During this time I used a SolidWorks assembly of the transmission obtained from Mr. Lerg to design the drivetrain.

To save both time and funds, I decided to reuse the CV axle assembly. I also reused a slightly modified version of the chain tensioning mechanism for the CV axle developed by Jon Wilson, a past leader of the Baja team. Reusing the CV axle assembly allows the old components that are used with the CV axle to be reused. The reusable components include the brake disk and caliper, bearing carriers, rear hubs, rear wheels, and the rear tires.

The final drivetrain component to be sourced was the clutch. Two options were investigated. The first option was a fully manual wet clutch. However, all manual clutches are built directly into the engine block. I discussed building a manual wet clutch unit with Mr. Lerg at length. However, it was determined that building a custom housing and actuation system for a clutch would be nearly impossible given time constraints on the project. The second clutch system that was investigated was a bell type centrifugal clutch. These are automatic clutches that bolt directly onto the engine output shaft and have a sprocket attached to their output. They consist of two parts as shown in Figure 9.

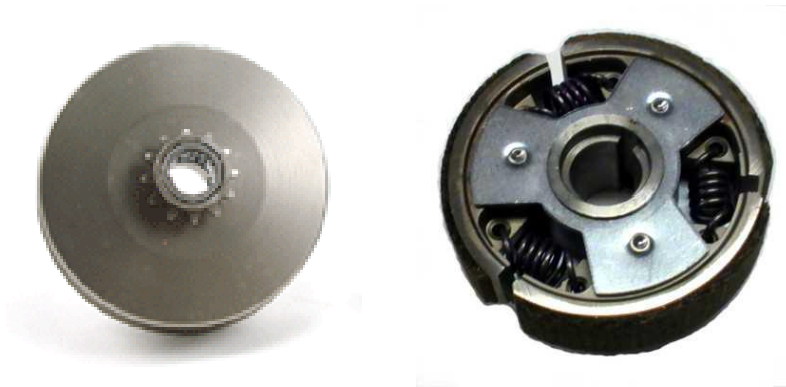


Figure 9: Centrifugal Clutch Drum (left) and Rotor (right)

As seen in Figure 9, the rotor assembly, which mounts securely on the engine shaft, contains pressure plates that move out due to centrifugal force as the speed of the engine increases. The drum is placed over the rotor. As the plates move out, they come in contact with the drum and cause it to rotate. The faster the engine rotates, the stronger the plates push against the drum which will lock the engine output to the clutch's output. The drum has an attached sprocket which is then linked to the transmission input by a chain. In conclusion, a centrifugal clutch allows the engine to idle at low RPMs and become fully engaged at higher RPMs. The engagement point can be adjusted by using springs of different stiffnesses. It was determined that this system would be the ideal one to use. Due to the nature of the clutch, it also prevents

the engine from stalling. This characteristic is a desirable one because if a car stalls during an official run, its score is a zero for that run. This clutch will also enable drivers who do not know how to drive a manual transmission to drive the car with ease.

The clutch that was chosen was the Noram Enforcer Clutch. I selected it for many reasons. First it has a 1 inch bore, the same as the engine output shaft which will make for easy installment. It also is rated up to 40 HP, so it will be able to handle the power of the engine, without causing wear on the clutch. Finally, it has a 10 tooth sprocket that can be used with 420 chain. This sprocket size and chain type is ideal. The small sprocket size will allow it to easily gear the system down. Also, the type of chain is strong and well suited to this application.

After selecting all of these systems, I made an initial layout of the drivetrain. This layout is shown in Figure 10.

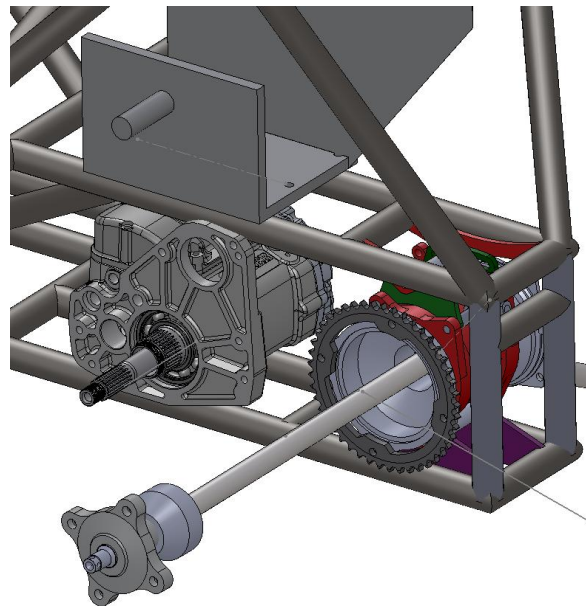


Figure 10: Initial Drivetrain Layout

The transmission as seen in the figure has two concentric shafts. The inner shaft is the input, and the outer shaft is the output. A chain will run from the centrifugal clutch on the engine to the input shaft on the transmission. A second chain will run from the output shaft to the sprocket on the CV Axle to drive the axle. The chain used to go from the clutch to the transmission input

was determined to be 420 racing chain. This chain is capable of transmitting the torque from the engine to the transmission. One issue that was encountered at this point was cutting splines into a sprocket to fit on the transmission. To do this I worked with Paul Tompkins, a machinist at Union College, to water-jet two spline cutouts into $\frac{1}{4}$ inch hardened steel as seen in Figure 11.

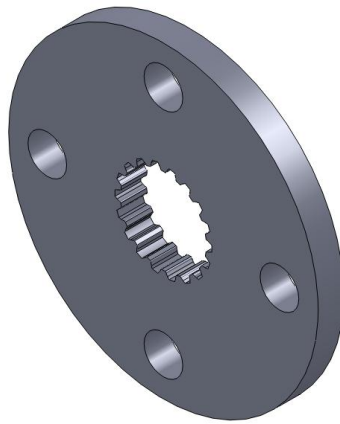


Figure 11: Spline Adapter

Next, an ANSI #40 45 tooth sprocket blank was obtained from McMaster-Carr and the center was milled out. Then the $\frac{1}{4}$ inch hardened steel plates with the splines cut into them were made into hubs and bolted to the sprocket. Figure 12 shows the plates that were cut and how they bolt onto the sprocket to securely attach it to the transmission shaft.

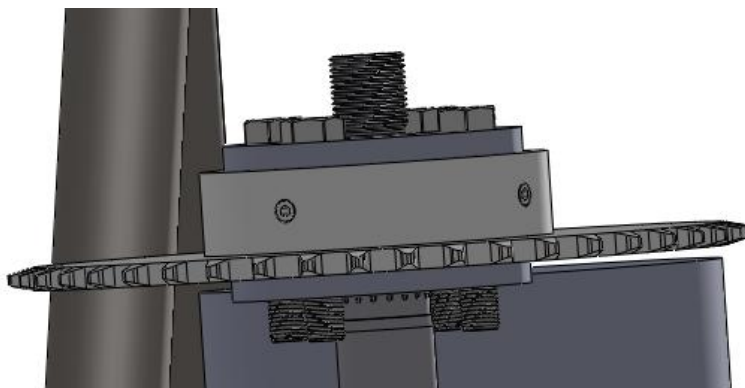


Figure 12: Spine adapters bolted to sprocket

In order to tension the chain from the clutch to the transmission input, an engine mounting plate was designed. This mounting plate was made of 3/8" 6061 aluminum and bolted securely to the frame. Slots were put into the mounting plate to allow the engine to be moved forward and backward in order to tension this chain. This plate is shown in Figure 13.

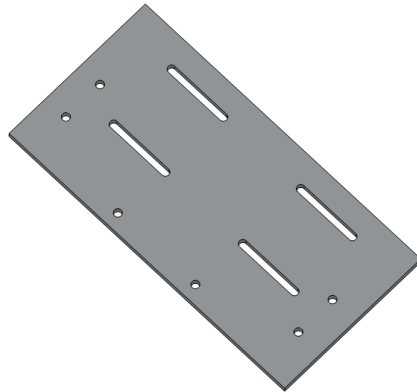


Figure 13: Engine Mounting Plate

As seen in Figure 13, the engine mounting plate uses slots for the engine to bolt to. These slots allow the engine to be moved up to three inches in order to properly tension the chain.

The second chain and sprocket set goes from the transmission output shaft to the drive axle. The company that built the transmission also included a 19 tooth size 530 chain sprocket that fit perfectly on the transmission shaft. Since 530 sprocket dimensions are the same as ANSI #50 sprockets, a 45 tooth ANSI #50 sprocket blank was ordered from McMaster-Carr to be attached to the CV axle. This sprocket's center was then milled out using a CNC milling machine. The mounting bolt holes were milled and countersunk into the sprocket as well at this time. The custom sprocket can be seen in Figure 14.

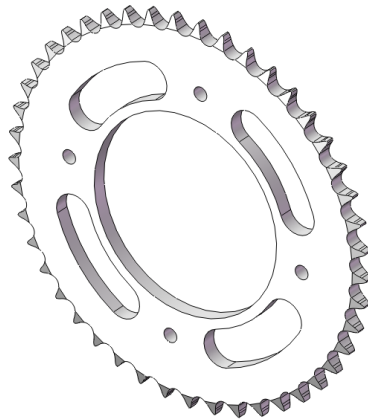


Figure 14: Custom Sprocket that Mounts To Axle Assembly

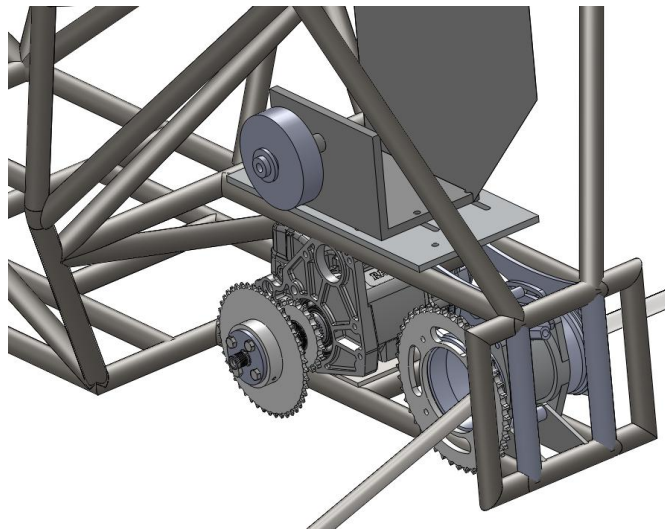


Figure 15: Final Drivetrain

Figure 15 shows the final design of the drivetrain. The gray box on top of the engine mounting plate represents the engine. The clutch, as seen in Figure 9, slides onto the engine shaft and is bolted fast and can be seen on the end of the engine shaft. The transmission has two concentric shafts. One chain will connect the clutch to the input shaft on the transmission. A second chain will connect the output shaft of the transmission to the sprocket on the CV Axle to

drive the axle. In order to ensure that the sprockets and components all lined up, a FaroArm was used to precisely measure all bolt patterns and the offsets of critical components from the bolt pattern.

The entire drive system has an efficiency of 92%. In other words, of the 10 hp that the engine puts out, 9.2 hp will go directly to drive the wheels. This drivetrain will allow the system to put out a maximum of 440 ft-lbs of torque in first gear and will have a top speed of 27mph in fifth gear. To get an idea of how much torque this is, the car will be able to accelerate at 6.2m/s^2 in first gear.

Suspension Design:

Fall 2010 Design

I determined that a double A-arm style suspension system would best serve the needs of this project. It is light weight, adjustable, and has extremely good suspension travel characteristics. Many teams have used suspensions like this one in the past and have had success.

Before designing the suspension I determined that in order to increase the strength of the A-arm system, a rake of 14° should be incorporated in the design. A rake is when the plane that the suspension travels through is not perpendicular to the road surface, but rather at a laid back, or raked, angle. This rake allows bumps to be absorbed by the suspension, rather than be taken head on. Raking back the suspension will also provide better power delivery. In other designs when the car accelerates, the rear section of the car sags down, slowing the car's acceleration. This scenario will not happen with a raked back A-arm suspension, because the suspension will not compress during acceleration, but rather will remain rigid.

As seen in Figure 7 I needed to design a bearing carrier to use this type of suspension. I designed a system that would clamp onto the bearing carrier that the team already had in order to save on cost. This system is shown in Figure 16.

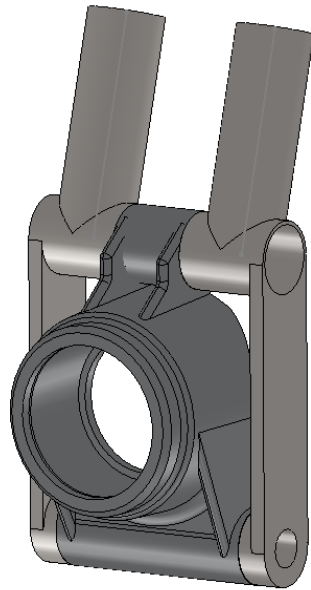


Figure 16: Rear Bearing Carrier Assembly

Figure 16 shows the modified rear bearing carrier assembly. The center piece is from a Polaris Outlaw and is made to fit the CV axle that the design uses. The two outside pieces are made of chromoly steel. The next section to be designed was the A-arms. I determined that it would be best to make them the same length. With the arms being the same length, 0° of camber will be seen throughout the travel of the suspension; meaning that the tire will remain perpendicular to the ground at all times. This camber can be adjusted by changing the lengths of the A-arms. By increasing the bottom A-arm's length, or shortening the upper A-arm's length, an increasing negative camber will be induced throughout the travel of the suspension. Negative camber is ideal for a track course where cornering is more important than the ability to go over obstacles. I foresee the final product, after testing and tuning, to have a slight negative camber. In order to make the lengths adjustable, heim joints were utilized. The suspension design can be seen in Figure 17.

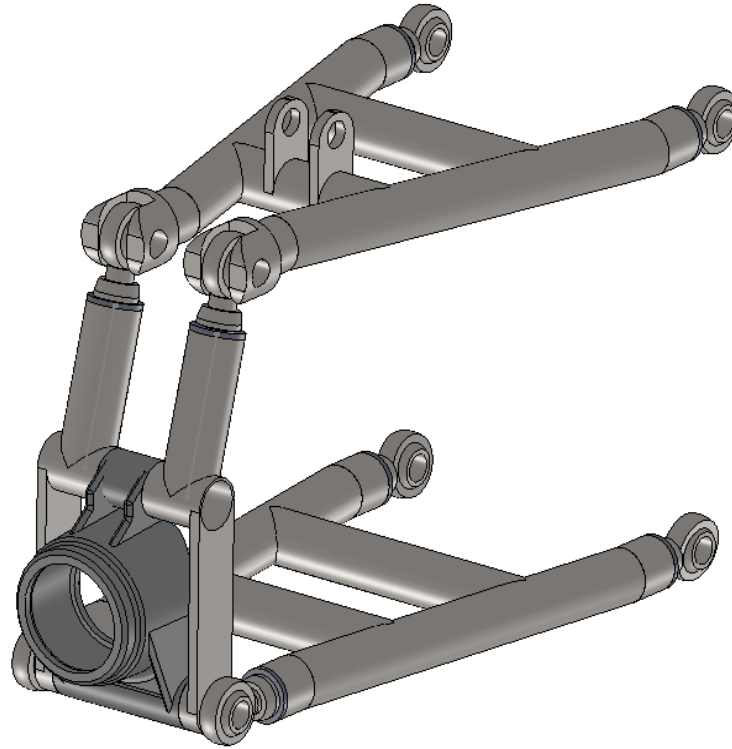


Figure 17: Rear A-arm suspension design

The heim joints screw into the ends of the A-arms, and can extend to slightly over an inch, allowing the suspension to be very adjustable. To increase the negative camber as stated before, both ends of the bottom arm could be lengthened to add a total of two inches to the lower link, creating more than enough adjustability.

To assemble this suspension, two long bolts will go through the bottom and top sections of the bearing carrier. Bolts and spacers will be used to connect the remaining heim joints. In order to incorporate the 14° rake, the rear framing will need to be adjusted. Figure 18 shows how the suspension will look in its raked back state on the frame.

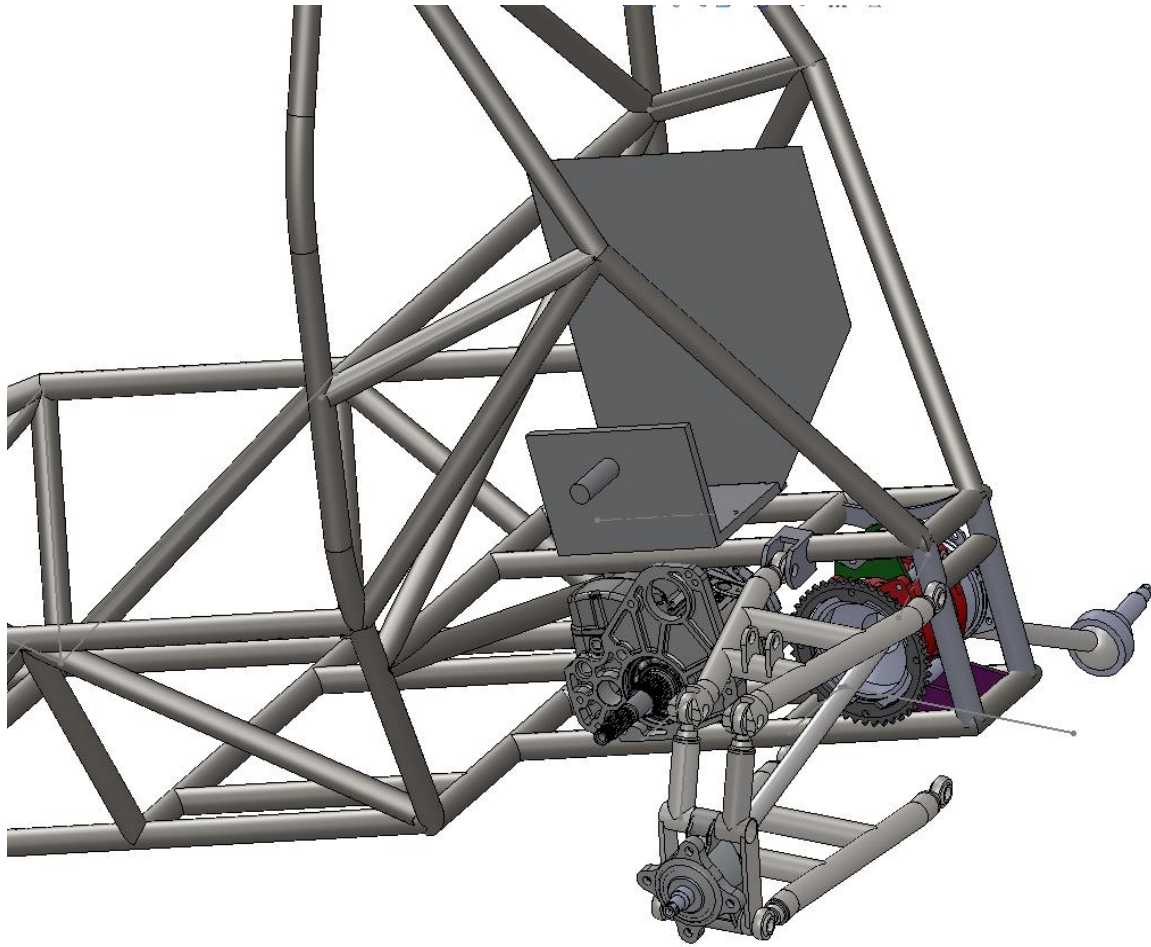


Figure 18: Suspension design with frame

Figure 18 shows the extent of my design progress for the fall term of my project. The suspension is in the raked back position that I designed it for. A sample attachment bracket was included for demonstration purposes and can be seen attached to the upper left heim joint. However, when I tried to finalize the design, the suspension would not fit with the drivetrain. The rear sprocket ended up being bigger than originally thought which caused the A-arms to interfere with the chain. Also, as seen in Figure 18, the suspension attachment points would be difficult reach. These issues, combined with the excessive use of heim joints which increased the chance of something breaking, led me to make a drastic change to the suspension design.

Suspension Redesign

At the beginning of winter term I decided to change the suspension to a semi-trailing arm suspension. This suspension is stronger, can absorb impacts better, is easier to fabricate, and, most importantly, can be made to work with the drivetrain. As previously stated, our team has used this suspension style before and so I needed to make significant design changes to the old suspension to avoid losing design points. A semi-trailing arm suspension is made up of three members: a trailing arm and two control arms. I started my design by specifying the length of the upper (12.5 ") and lower (13") control arms. By making the bottom control arm longer than the top one, I induced a negative camber that increases throughout the travel of the suspension. The control arms are made of 1" chromoly tubing with 1/8" walls. The ends of these members will have heim joints which will allow their lengths to be adjustable, in turn, allowing the camber of the suspension to be adjusted. The next part was to design the trailing arm. In order to make sure that my design had no interference with the drivetrain, I decided to mount it to a lower frame-rail further up on the frame. The trailing arm design is shown below in Figure 19.



Figure 19: Trailing Arm Design

This trailing arm bolts onto the bearing carrier of a Polaris Outlaw that our team has used in the past. By using the same bearing carrier fewer new parts needed to be purchased, saving the team money. The trailing arm is made of the same material that was used to fabricate the frame; 1.25" 1/16 wall thickness chromoly tubing. Figure 20 shows the bearing carrier, trailing arm, and two control arms assembled together.

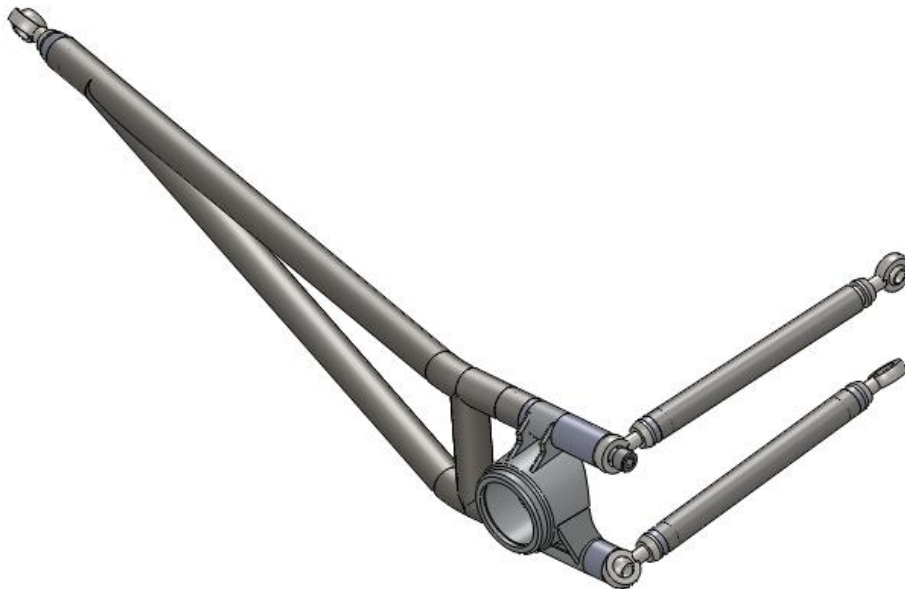


Figure 20: Rear Suspension Assembly

As seen in Figure 20, this semi-trailing arm suspension has only 5 heim joints as opposed to the 8 that the double A-arm suspension had. Also, when encountering obstacles there is much less chance of the heim joints failing compared to the A-arm suspension previously designed. The chief advantage of this suspension is that it easily fits around the drivetrain. A full assembly of the drivetrain and the suspension can be seen in Figure 21.

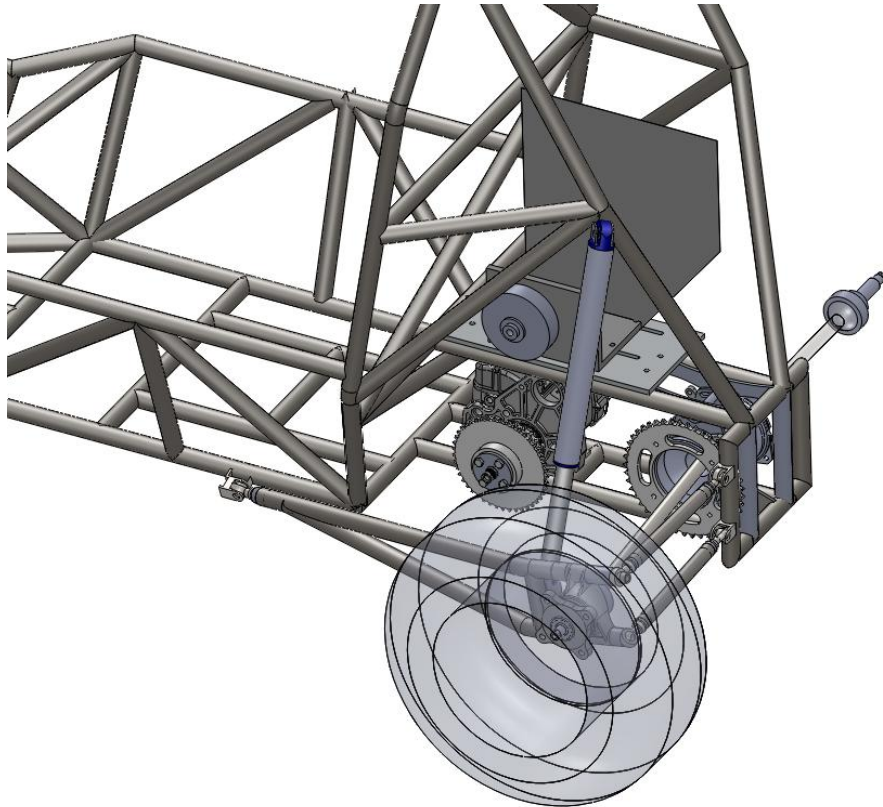


Figure 21: Full Assembly

The shock used in this suspension is a Fox Air Shock 2.0 (seen in Figure 21). This shock is highly adjustable, lightweight, durable, can extend up to 10". Our team already owns a set of these shocks, so they just need to be rebuilt. A seal rebuild kit has already been ordered, and the shocks will be rebuilt at the beginning of next term.

I then performed a finite element analysis on the trailing arm component of the suspension. A static analysis was performed on the member to simulate hitting an obstacle, like a fallen tree, that hits the tire and puts a great deal of stress on the trailing arm member. For boundary conditions the point where the trailing arm attaches to the frame was grounded and the trailing arm was pulled backwards where it attaches to the bearing carrier. A 3G force was used to simulate the impact. The results of the finite element are shown in Figure 22.

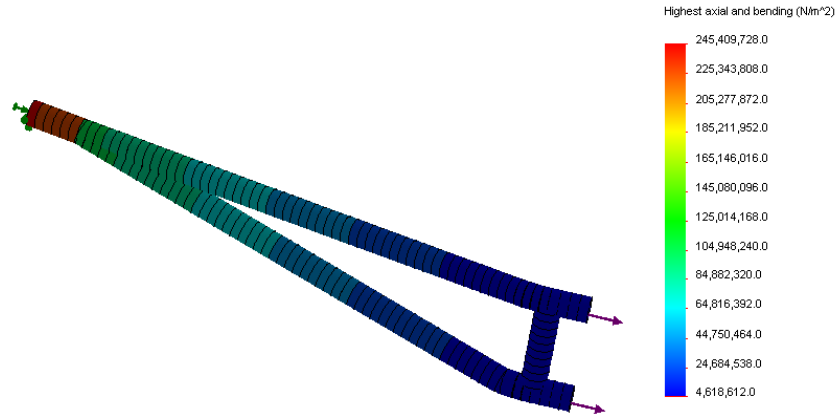


Figure 22: Finite Element Analyses of Trailing Arm

From the finite element analysis the minimum factor of safety for the trailing arm was found to be 1.9.

The final suspension design is fully independent and provides 12” of travel at each wheel. Figure 23 shows the suspension’s full range of travel.

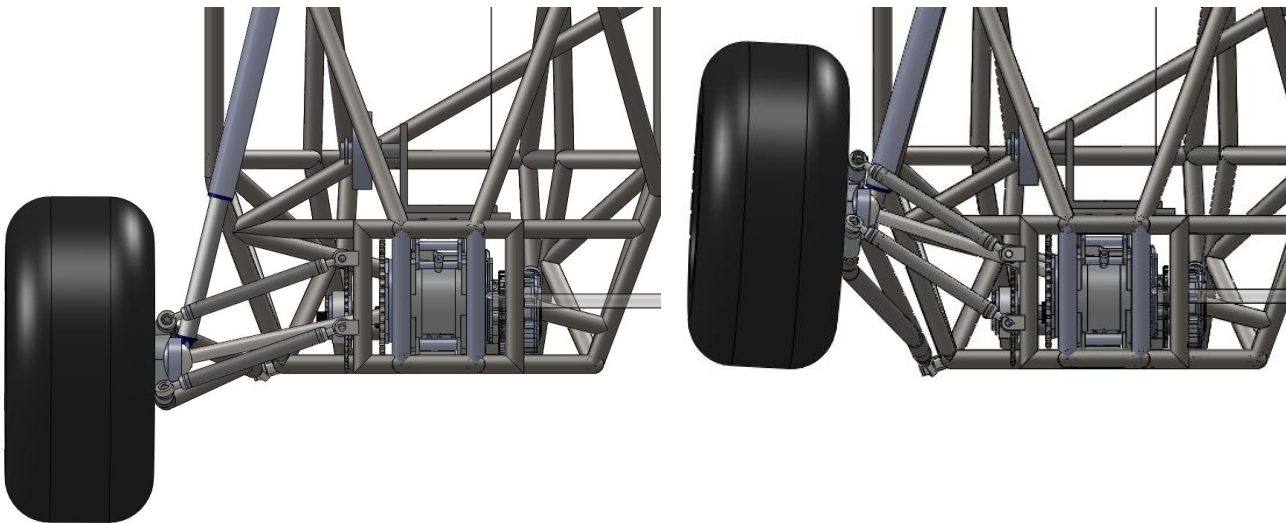


Figure 23: Suspension shown fully extended and fully compressed

Fabrication Thus Far:

This term I have worked with the machine shop to fabricate the frame and drivetrain. A picture of the current progress of the fabrication is shown in Figure 23.



Figure 24: Fabricated Drivetrain and Framing

In Figure 24, the progress made on the fabrication is shown. All of the framing required to house the drivetrain and suspension has been completed. Additionally all drivetrain components have been purchased, fabricated, and installed.

Cost Evaluation

In an effort to save money, I reused as many components from old Baja cars as I could. Table 2 shows what was spent to complete my project.

Item	Cost
Framing	\$ 570.00
Transmission	\$ 2,400.00
Sprockets	\$ 78.00
Materials	\$ 121.00
Heim Joints & Fasteners	\$ 210.00
Shock Rebuild Kit	\$ 53.00
Total Spent	\$ 3,432.00

Table 2: Cost of Project

As seen in Table 2, my senior project cost \$3,432.00 to build. This amount is under my initial estimate for the project because I was able to reuse most of the parts needed to complete my project.

Work for Next Term:

At the beginning of next term I will work with the machine shop to fabricate and assemble the rear suspension components. This work also includes rebuilding the shocks that will be used. I will also design and fabricate a shifting linkage needed to actuate the transmission. Finally, I will complete all of the other miscellaneous details of the project such as fabricating and installing chain guards as required by SAE.

Publication:

My work will be presented at the regional SAE Baja competition at the University of Pittsburgh in Kansas. This event is being held May 26-29, 2011. At this event I will be submitting a formal design report, as well as completing a formal design review and sales presentation. I will also be presenting this work at the Steinmetz Symposium this May. This term I also participated in the ASME speaking competition where I gave a presentation about my senior project. I have also discussed my senior project with the rest of the Union College Baja team at length. Furthermore, I have adhered to all requirements and guidelines set forth by the

Mechanical Engineering department and will submit this thesis that conforms to the Schaffer Library specifications to the Library in order to make myself eligible to graduate with honors.

Conclusion

This term I finalized the design of the drivetrain. It is capable of producing 440 ft-lbs of torque in first gear. In its highest gear it will be able to propel the car, estimated at 300kg, at 27mph. The drivetrain is lightweight, includes a reverse, and is extremely efficient. I have also designed the rear suspension. The rear suspension is strong, lightweight, adjustable, and does not cause any interference. This suspension is fully independent and allows up to 12" of travel for each wheel. I have also designed a frame that holds all of these components in place. Figure 25 shows the completed design of my project.

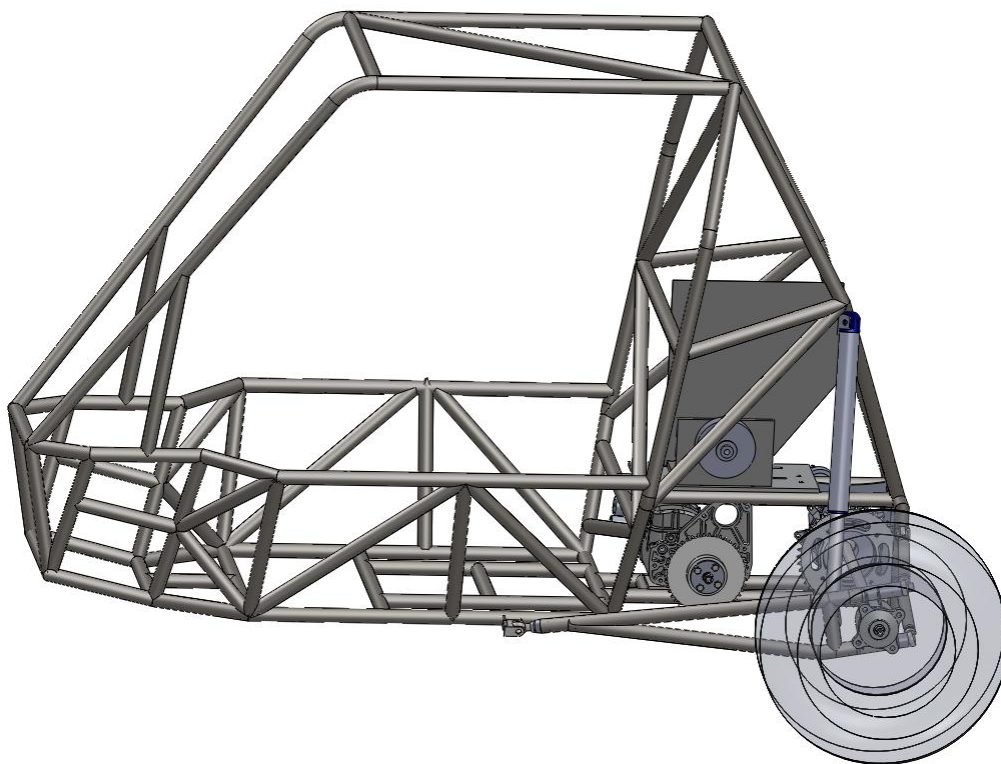


Figure 25: Complete Design of Project

Over the course of the winter term I worked with the machine shop to successfully fabricate the frame. I also worked with the machine shop to fabricate and assemble the drivetrain in its entirety. Next term I will continue my project by working with the machine shop to fabricate the suspension components as well as complete the final details of the project.

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I would like to acknowledge the following people and organizations for helping me with my project.

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