Research

Goal: To understand the theory, parts, and requirements of your subsystem. To understand what's been done before, what is possible, and where we are in your subsystem. To learn the basics so you can build a good foundation and take this subsystem to new levels.

Reminder: Your goal should not be to just fill this template out. Your goal is to learn. If you don't know how to fill a section out, work to understand it with your subsystem lead.

Phase 1: Pre-Design Analysis

Objective of System

Write down the objective of the subsystem.
The objective of this subsystem is to deliver the source of power, which is its engine transmission power, to the vehicle's rotating wheels in order for the car to move. It is mainly the system concerned with the distribution of electromechanics within power generation from the engine to the axles.

Team Goals

Car Goals:

- Reliability
- Driveability
- Manufacturability
- Serviceability
- Safety

Requirements

Document how your subsystem will meet the overall team and car goals (What must your system do to meet these goals?) Consider how you would quantify these requirements by setting targets (quantifiable requirements) for your subsystem.

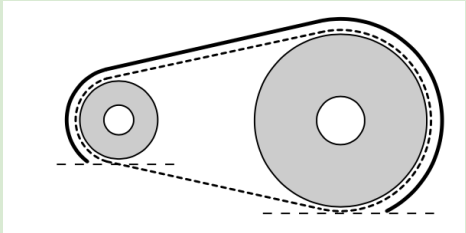
What must the Subsystem do?	**Quantifiable Requirement?**	**Related Car Goal**
Transfer the power generated by the electric motor to the wheels	Depending on the power generated by the motor and the final	Reliability, Driveability

	drive.	
Withstand forces exerted by the interfacing systems	Factor of Safety	Reliability, Safety
Consistently and smoothly turn the wheels	----	Driveability, Serviceability
Have parts that are easily maintainable and manufacturable.	----	Reliability, Manufacturability, Serviceability

Rules

Go to fsaeonline.com and download the latest version of the rules. List the rules that are applicable to your subsystem in the following table.

Rule #	Rule
IC.1.1.2	**Hybrid powertrains, such as those using electric motors running off stored energy, are prohibited.**
T.8.2	**Critical Fastener Requirements**
T.8.2.1	Any Critical Fastener must meet, at minimum, one of the following: ● SAE Grade 5 ● Metric Grade 8.8 ● AN/MS Specifications ● Equivalent to or better than above, as approved by a Rules Question or at Technical Inspection
T.8.2.2	All threaded Critical Fasteners must be one of the following: ● Hex head ● Hexagonal recessed drive (Socket Head Cap Screws or Allen screws/bolts)
T.8.2.3	All Critical Fasteners must be secured from unintentional loosening by the use of **Positive** **Locking Mechanisms** see **T.8.3**
T.8.2.4	A minimum of two full threads must project from any lock nut.

T.8.2.5	Some Critical Fastener applications have additional requirements that are provided in the applicable section.
T.8.3	**Positive Locking Mechanism**
T.8.3.1	Positive Locking Mechanisms are defined as those which: ● Technical Inspectors / team members can see that the device/system is in place (visible). ● Do not rely on the clamping force to apply the locking or anti vibration feature. *Meaning If the fastener begins to loosen, the locking device still prevents the fastener coming completely loose*
T.8.3.2	Acceptable Positive Locking Mechanisms include, but are not limited to: ● Correctly installed safety wiring ● Cotter pins ● Nylon lock nuts (where temperature does not exceed 80°C) ● Prevailing torque lock nuts *Lock washers, bolts with nylon patches and thread locking compounds (Loctite®), DO NOT meet the positive locking requirement.*
T.5.1	**Transmission and Drive** ● transmission and drivetrain may be used.
T.5.2.1	Exposed high speed final drivetrain equipment such as Continuously Variable Transmissions (CVTs), sprockets, gears, pulleys, torque converters, clutches, belt drives, clutch drives and electric motors, must be fitted with scatter shields intended to contain drivetrain parts in case of failure.
T.5.2.2	**Drivetrain Shields and Guards** The final drivetrain shield must: ● Be made with solid material (not perforated) ● Cover the chain or belt from the drive sprocket to the driven sprocket/chain wheel/belt or pulley. Start and end no higher than parallel to the lowest point of the chain wheel/belt/pulley: 

T.5.2.3	Body panels or other existing covers are acceptable when constructed per **T.5.2.7** / **T.5.2.8**
T.5.2.4	Frame Members or existing components that exceed the scatter shield material requirements may be used as part of the shield.
T.5.2.5	Scatter shields may be composed of multiple pieces. Any gaps must be small (< 3 mm)
T.5.2.6	If equipped, the engine drive sprocket cover may be used as part of the scatter shield system.
T.5.2.7	Chain Drive - Scatter shields for chains must: ● Be made of 2.66 mm (0.105 inch) minimum thickness steel (no alternatives are allowed) ● Have a minimum width equal to three times the width of the chain ● Be centered on the centerline of the chain ● Remain aligned with the chain under all conditions
T.5.2.8	Non-metallic Belt Drive - Scatter shields for belts must: ● Be made from 3.0 mm minimum thickness aluminum alloy 6061-T6 ● Have a minimum width that is equal to 1.7 times the width of the belt. ● Be centered on the centerline of the belt ● Remain aligned with the belt under all conditions.
T.5.2.9	Attachment Fasteners - All fasteners attaching scatter shields and guards must be 6mm or 1/4” minimum diameter **Critical Fasteners**, see **T.8.2**
T.5.2.10	Finger Guards ● Must cover any drivetrain parts that spin while the vehicle is stationary with the engine running. ● Must be made of material sufficient to resist finger forces. ● Mesh or perforated material may be used but must prevent the passage of a 12 mm diameter object through the guard.

Lessons Learned

Go through the design binder for your subsystem and the 2021 Lessons Learned sheet and document the lessons learned that pertain to your subsystem. Comment on how they will be rectified in the table below.

What was wrong with the previous design?/Areas to Improve?	How will this be rectified?

Accumulator was not put on priority at that time, that is why delays were initially caused.	Lots of effort needs to be put on the Accumulator as lots of systems depend on it.
The manufacturing parts of the subsystem needs to be more reliable and maintainable such as the manufacturing of tripod bearings.	further investigate bearing inspection, options and what the best grease to use is
“Should have given more time to explore different sprocket carrier geometries”	Plan ahead on the design and then quickly decide what geometry is **durable and lighter**, which is suitable for the car.
“We are wasting money if we are buying components we can't find”	Keep track of parts using some sort of inventory so you know what you have and where it is.

Resources

Use the following resources as a guide to conduct your detailed design. Document ALL resources you find that are useful for the system.

red = useful information

Source Title	Chapter #'s	Completed
Race Car Vehicle Dynamics	20	complete
TU Eindhoven Drivetrain Design 2009	All	complete
GFR Drivetrain Design 2016	All	complete
RF18 Diff Carrier Design	All	complete
RF18 Sprocket Carrier Design	All	complete
https://www.youtube.com/watch?v=bgGgH0j0KQE	All	complete
https://www.youtubeCar Gears - Explained.com/watch?v=ILGPHI1o0bc	Entire video	complete
https://www.youtube.com/watch?time_continue=143&v=yYAw79386WI&feature=emb_logo	2:20 to 7:20 is the meat and potatoes	complete
https://www.youtube.com/watch?v=PEdnH7_7_yc	Entire video	complete
MIT EV Powertrain System	All	complete
https://murmotorsports.eng.unimelb.edu.au/news-and-events/news-and-events/mur-blog-electric-drivetrain-a-new-beginning	All	complete
https://www.koreascience.or.kr/article/JAKO200708410644212.pdf		
http://www.superstreetonline.com/how-to/engine/modp-1005-drivetrain-power-loss/		complete
http://www.fsae.com/forums/archive/index.php/t-1117.html?s=2f4ac3793225a1cc9fb6f05198249449		
https://www.taylor-race.com/technical		complete

-resources		
Michael Salameh differential understand and comparison	all	complete
SAE gear ratio formula		complete
KHK Basic Gear terminology and calculations		complete
Illinois UC Paper on CV Joint Forces and Friction	All	

Other Research Sources:

- From RFR
  - Design DriveTrain Binder
  - EV Powertrain Presentation
- Reputable Sources
  - https://web.wpi.edu/Pubs/E-project/Available/E-project-042418-112306/unrestricted/Design_and_Optimization_of_a_Formula_SAE_Vehicle.pdf
  - https://cpb-us-w2.wpmucdn.com/sites.udel.edu/dist/e/299/files/2011/08/FSAE_PowerTrain_Phase_4_NN.pdf
  - https://portfolium.com/entry/2019-formula-sae-differential-carrier-redesign
  - https://scholarscompass.vcu.edu/cgi/viewcontent.cgi?article=1063&context=capstone

Phase 2: Detailed Research

Use the sources above and conduct research to understand the theories behind each item listed below. Answer the guiding questions to learn more about the subsystem. Investigate/brainstorm concepts and existing designs for the items. Include pictures and videos that assist in your understanding and visual understanding of the part and its function.Make sure to investigate what other teams do and what our team has done previously.

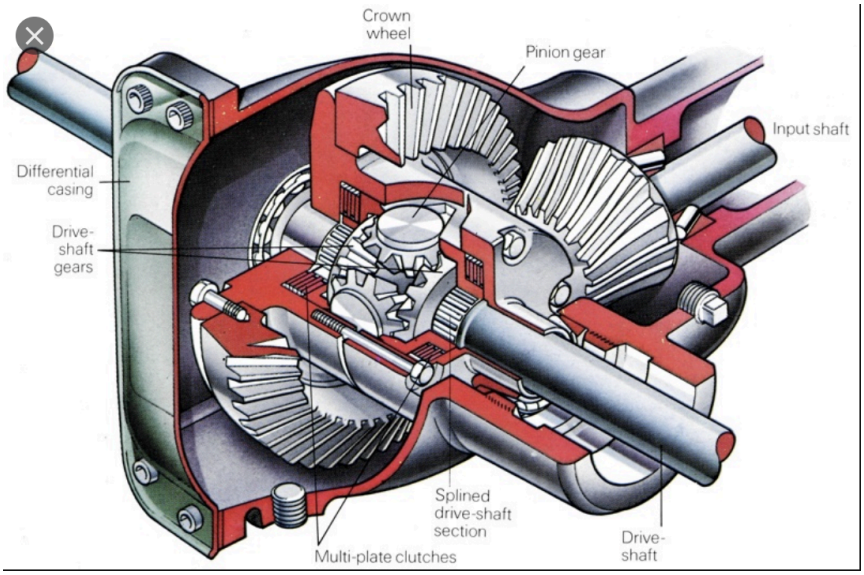
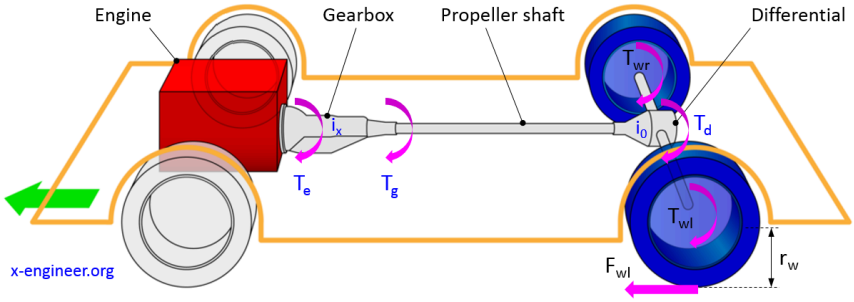
Main questions: What function does the part serve? How does it work? What does it integrate with? Why is it essential to have it in the car? What does it look like?

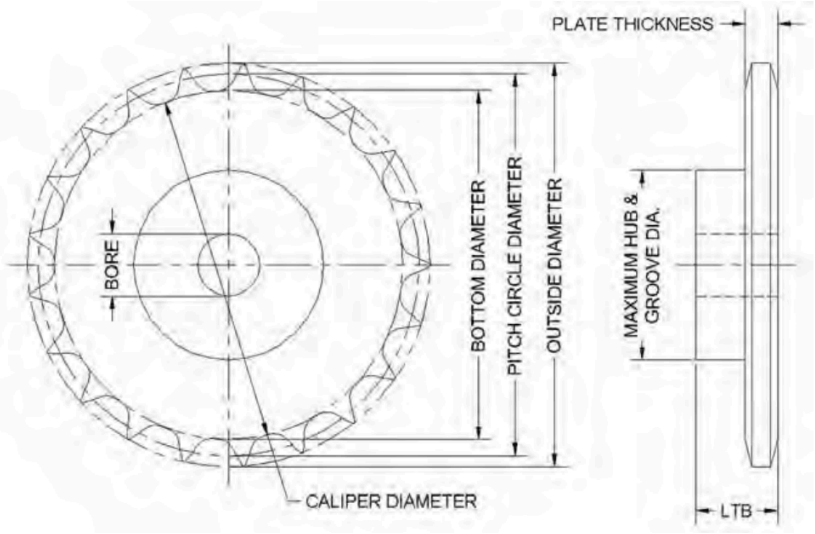
General Terms and Definitions

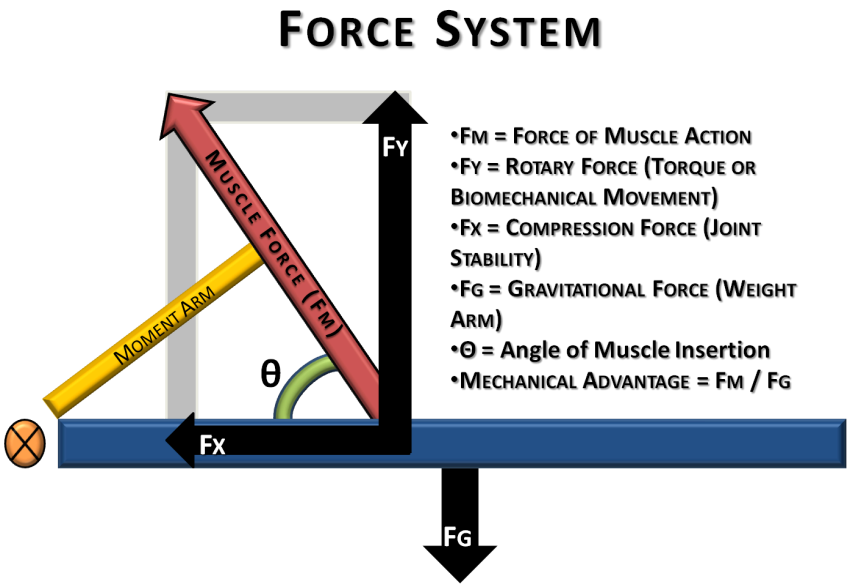
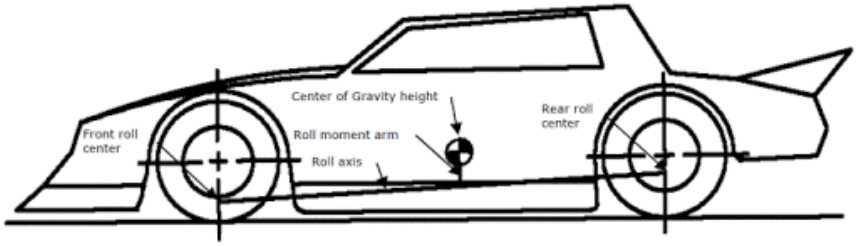
Know how to identify them and explain it

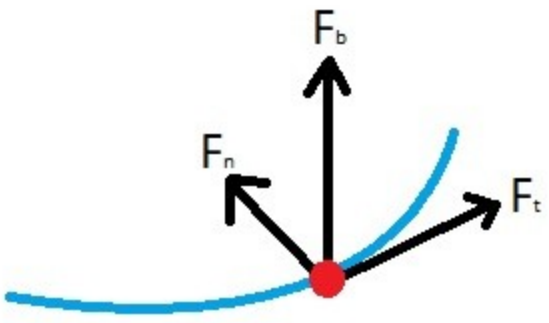
Resources:

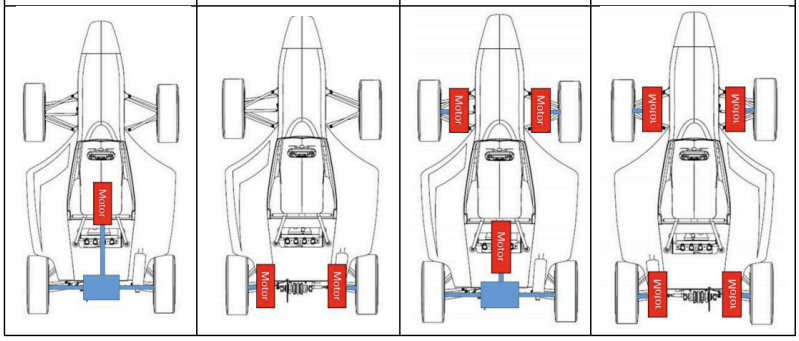
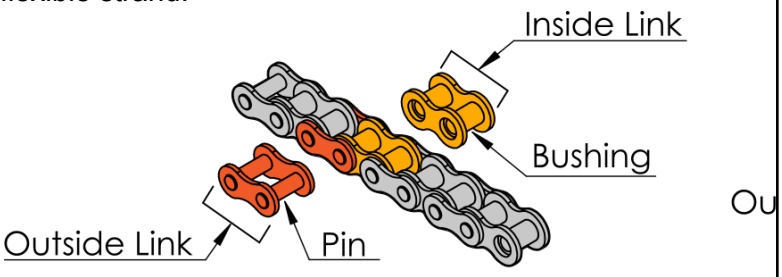
- https://www.popularmechanics.com/cars/how-to/a250/1302716/

Term	Definition/Explanation
Final Drive	• A final drive unit is the largest part of a transmission system in a vehicle. The Final Drive is the last gearing used while transmitting the engine power to the wheels. • It is located in the rear of the machine's undercarriage opposite of the blade. • The Final drive contains a pair of spiral-bevel gears comprising a pinion that connects to the propeller shaft and a ring gear that connects to a flange on the differential case. 
Torque	• **Torque** provides a simple measurement of the maximum twisting force that an engine can generate, when worked hard. This is why pickup trucks have high-**torque** engines that generate more **torque** than a small **car**. • The engine's torque is useless if it doesn't get to the drive wheels through a complex maze of gears. 
Sprocket Terms	Source;

a. Minor diameter b. Pitch diameter c. Major diameter d. Pitch	● http://www.tsubaki.ca/pdf/E206-236_Sprocket_Technical_Section.pdf ● http://www.gizmology.net/sprockets.htm a. Minor diameter ○ is the diameter of a circle tangent to the curve (called the seating curve) at the bottom of the tooth gaps. b. Pitch diameter ○ is the diameter of the imaginary circle that passes through the centers of the link pins when the chain is wrapped around the sprocket c. Major diameter ○ is the diameter over the tips of the sprocket teeth. d. Pitch ○ Chain Pitch is the distance between the pin centerlines in a link of chain. ○ This distance is used to make the tooth profile of a sprocket, but cannot easily be measured on a finished sprocket. If the pitch of a sprocket is incorrect, the chain will not sit properly when wrapped around the teeth.  Sprocket Diagram
Moment Arm	Source; https://www.ptdirect.com/training-design/training-fundamentals/moment-arms-force-vectors-and-a-squat-analysis

	• A moment arm is the length between the line axis and line of force acting on the joint. • Force x Moment arm = Torque  
Tangential Force	Source; https://www.merriam-webster.com/dictionary/tangential%20force Definition: a force that acts on a moving body in the direction of a tangent to the curved path of the body.

	
Factor of Safety	Source; https://www.creativemechanisms.com/blog/factor-of-safety-in-design-and-engineering-the-basics ● Factor of safety (FoS) expresses how much stronger a system is than it needs to be for an intended load. ● "Factor of Safety" usually refers to one of two things: 1. the actual load-bearing capacity of a structure or component, or 2. the required margin of safety for a structure or component according to code, law, or design requirements. ● A very basic equation to calculate FoS is to divide the ultimate (or maximum) stress by the typical (or working) stress. $$\text{Factor of Safety} = \frac{\text{Strength}}{\text{Stress}}$$ **Example Solved** $$\text{Factor of Safety} = \frac{\text{Capacity}}{\text{Demand}}$$
Front and All-Wheel Drive	Source; ● https://www.autolist.com/guides/awd-vs-fwd ● https://commercialvehiclecontracts.co.uk/news/vehicle-technology/fwd-vs-rwd-vs-awd-vs-4wd-whats-the-difference **Front-wheel-drive (FWD):** In FWD vehicles, the engine

	powers the front axle. **All-wheel-drive (AWD):** AWD vehicles, the engine powers both front and rear axles. **TABLE 1**: *VIABLE POWERTRAIN CONFIGURATIONS CONSIDERED FOR LFS* **Powertrain 1** | **Powertrain 2** | **Powertrain 3** | **Powertrain 4** Rear wheels driven | Rear in-wheel motor hubs | One motor in the rear shaft and two front in-wheel motor hubs | Four in-wheel motor hubs 
Roller Chain	Source: - https://docs.revrobotics.com/15mm/transmitting-and-transforming-motion/sprockets-and-chain • Roller chain is used to connect two sprockets together and transfer torque. Roller chain is made up of a series of inner and outer links connected together which forms a flexible strand.  Ou •

General Concepts

1-2 Sentences explaining the concept

Concept	Explanation

How does final drive affect acceleration and top speed?	• A higher final drive ratio will create more torque which in turn produces more acceleration, however, more fuel is being consumed. • However, lower final drive ratio will lead to less torque at the wheels but a higher top speed.
How does sprocket sizing affect the final drive?	Source; https://medium.com/@BTO_SPORTS/how-to-decide-on-gearing-the-cause-and-effect-of-the-front-and-rear-sprocket-7dead807982e Gearing up increases speed thus lowering the final drive ratio. Use a larger rear sprocket or a smaller front sprocket to gear down. Reducing the gear ratio lowers the speed and raises the final drive ratio.
Explain the difference between a locked differential, an open differential, and a limited slip differential.	**Open differential:** The vast majority of rear-wheel drive cars have an open differential. This means that the rear wheels can spin independently of each other. **Locked differential:** allow both wheels to travel at the same speed, so when traction is lost for one wheel, both wheels will still keep spinning **Limited slip differential:** The wheels spins in the same direction.
How does final drive affect transmitted torque?	Source; https://www.motorauthority.com/news/1108398_learn-what-a-final-drive-ratio-is-and-how-it-affects-your-car • The final drive ratio is the last bit of gearing between your transmission and the driven wheels. • In general, a lower final drive ratio will lead to less torque at the wheels but a higher top speed. • Meanwhile, a higher ratio will result in the opposite, i.e. more torque at the wheels but a lower top speed.

Proposed Electric Powertrain Design

A drawing of the designed powertrain for the chosen configuration is shown in the below figure:

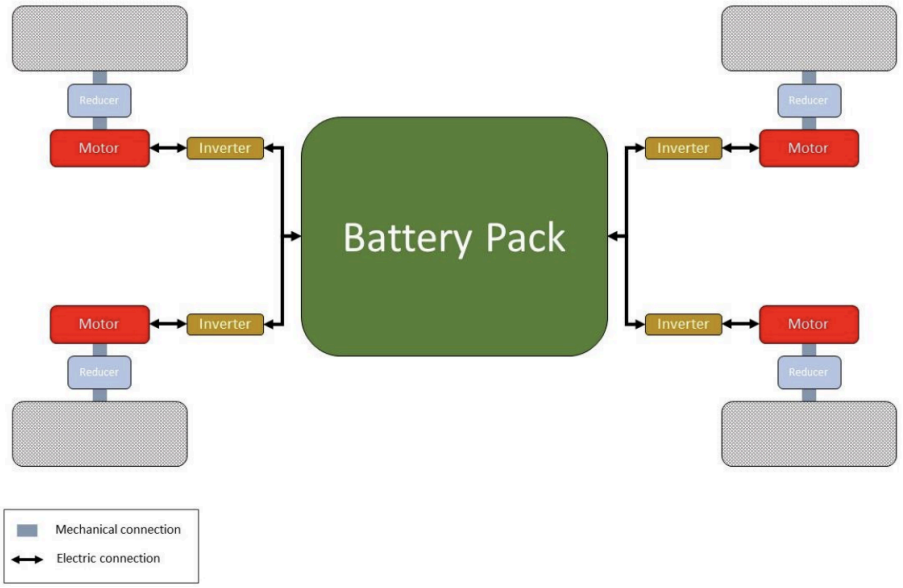


FIGURE 40: *POWERTRAIN 4 OVERVIEW*

As it can be seen, the powertrain consists of 4 main parts: The battery pack, the inverter, the motors and the reducers.

Source: https://upcommons.upc.edu/bitstream/handle/2117/171833/master-thesis.pdf?sequence=1&isAllowed=y

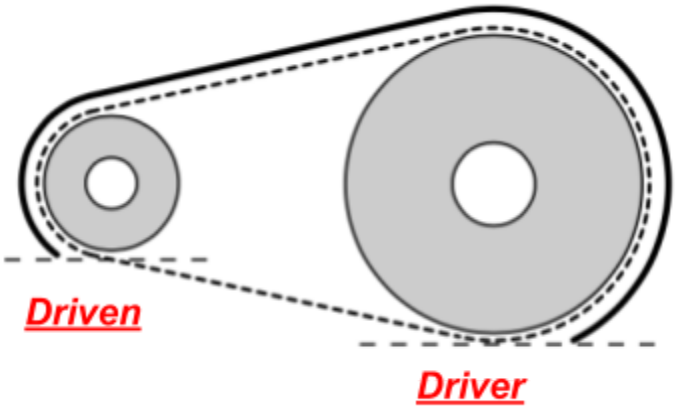
Sprockets

Sources:

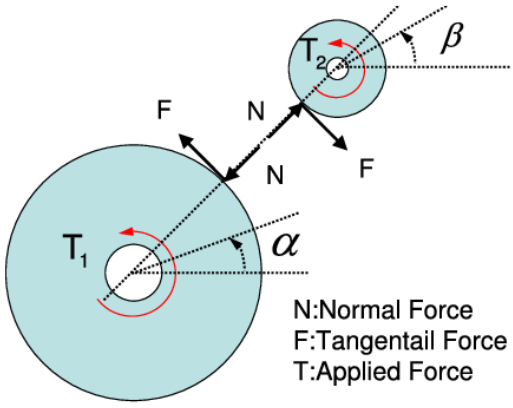
- https://medium.com/@BTO_SPORTS/how-to-decide-on-gearing-the-cause-and-effect-of-the-front-and-rear-sprocket-7dead807982e
- https://www.motohive.in/sprockets-easy-way-to-gain-speed-acceleration/
- https://www.mathworks.com/help/physmod/sdl/ref/chaindrive.html
- https://www.researchgate.net/figure/FREE-BODY-DIAGRAM-OF-TWO-GEAR_fig1_267491002
- GFR Drivetrain Design 2016

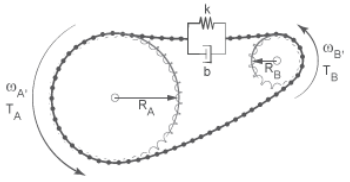
- **What is the purpose of the front sprocket and the rear sprocket?**

- Sprockets take the linear force from the drive chain and produce rotational energy to spin the spool. The diameter of the sprocket helps produce a moment arm to produce the torque on the spool.
- The front sprocket, the “driver”, transfers the gear power to the rear wheel via the roller chain.
- The rear sprocket, the “driven”, determines the overall top speed of the vehicle associated with power distribution to the rear wheels, the “driven” wheels.



- **What are the forces that would act on the sprockets? Provide a free body diagram.**





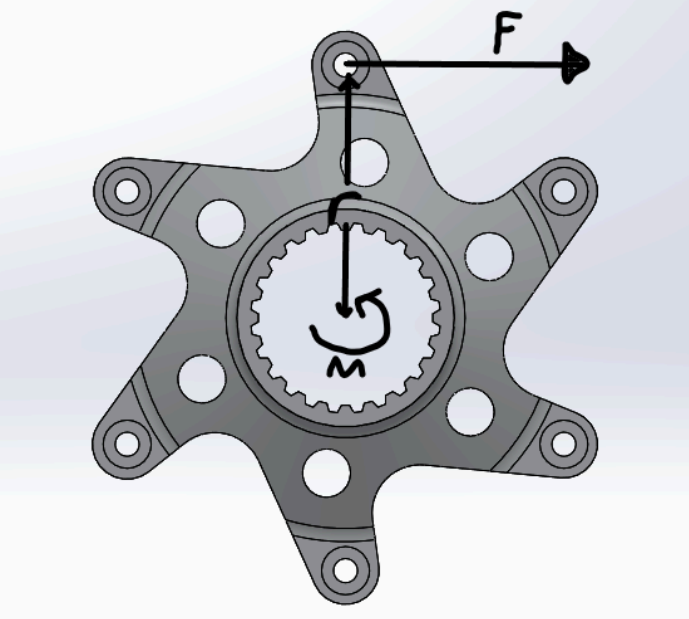
- A bigger rear sprocket/ smaller front sprocket will give you an increase in acceleration but decrease your top speed.
- A smaller rear sprocket/bigger front sprocket will reduce your acceleration but increase the ceiling for top speed.

Sprocket Carrier

- **What is the purpose of the sprocket carrier?**
    - This component is highly important to the vehicle design for two main reasons: its purpose in transmitting power to the rear wheels, and the high stakes of its manufacturing
    - Sprocket Carriers eliminate the rear wheel hub assembly and reduce flex of the rear sprocket. They are designed to give less drag and greater chain life and bolt directly onto sprockets.

    - Source
        - https://www.rscycles.com/category_s/372.htm
        - https://web.wpi.edu/Pubs/E-project/Available/E-project-042418-112306/unrestricted/Design_and_Optimization_of_a_Formula_SAE_Vehicle.pdf

- **What forces act on it? Provide a free body diagram.**



    - Source: https://web.wpi.edu/Pubs/E-project/Available/E-project-042418-112306/unrestricted/Design_and_Optimization_of_a_Formula_SAE_Vehicle.pdf

- **How is it attached to the sprockets as well as the rest of the system?**
    - The Sprocket Carrier is the component which connects the sprocket to the splines on the Drexler differential.

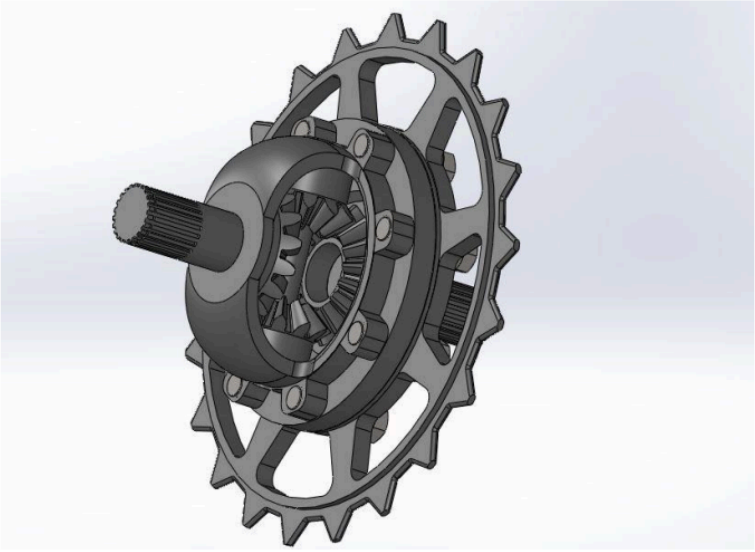


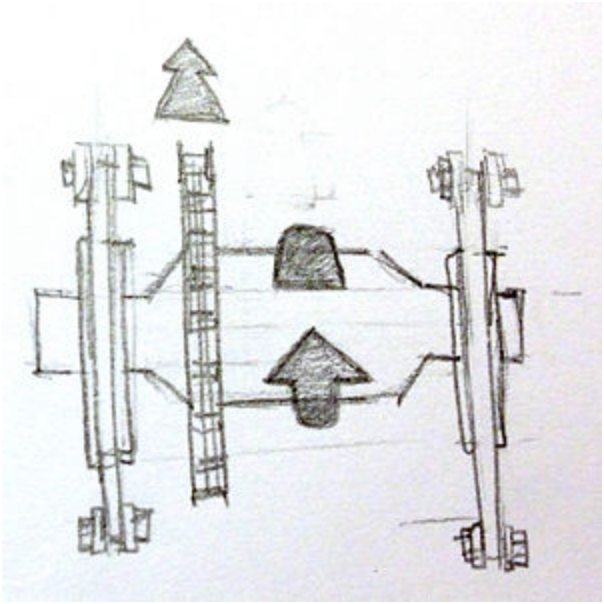
Fig. Sprocket-differential

-
- Source: https://www.irjet.net/archives/V6/i4/IRJET-V6I4991.pdf

Differential Carriers

- **What is the purpose of the differential carriers?**
  - Positioning the differential in the right spot while being able to withstand the chain forces.
  - Source: https://portfolium.com/entry/2019-formula-sae-differential-carrier-redesign

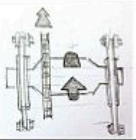
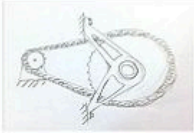
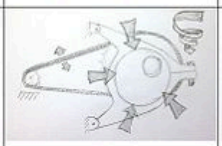
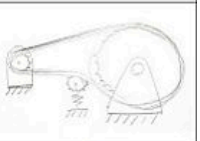
- **What forces act on them? Provide a free body diagram.**



- Source: https://wiki.ece.cmu.edu/ddl/index.php/Chain_drive_opportunity#Eccentric_Chain_Tensioner

- **Provide examples of how chain tensioning was implemented into prior diff carrier designs.**

  The main goal of the new differential mount design was to incorporate chain tensioning functionality into the mounts in order to reduce the complexity and weight of the system.
  - Linear tensioning with bolts in slots - mounts held in place by bolt torque
  - Rotational tensioner – pivot mount around top or bottom frame tabs, adjust with turnbuckle
  - Eccentric bearing cups – pivot diff within fixed mount, hold in place with pinch bolts

Description		CMR 57 Design	Hard Mounted Differential	Eccentric Clamp Pressure	Indexable Pivot Pretensioner	Spring Pretensioner
Sketch						
Criteria	Weight	Datum	Design 1	Design 2	Design 3	Design 4
Weight	3	0	+	+	0	-
Manufacturability	2	0	0	-	0	-
Adjustability	1	0	--	+	0	++
Ease of Use	2	0	0	++	++	++
Robustness	3	0	+	0	0	0
Adaptability	1	0	+	+	0	+
Compatibility	1	0	+	++	0	+++
Cost	1	0	+	-	0	-
Total Positive		0	9	11	4	10
Total Negative		14	4	3	12	3
Total Neutral		0	2	3	0	6
Net Score		0	7	8	4	4

Differential Mounting with Chain Tensioning Force Concept

Source:

- https://web.wpi.edu/Pubs/E-project/Available/E-project-042418-112228/unrestricted/Design_and_Optimization_of_a_Formula_SAE_Vehicle.pdf
- https://wiki.ece.cmu.edu/ddl/index.php/Chain_drive_opportunity#Eccentric_Chain_Tensioner

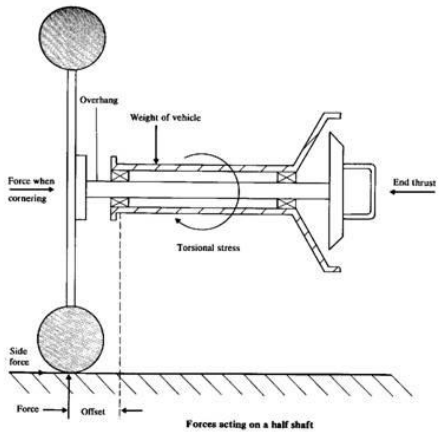
- **How do they interface with the rest of the system?**
  - By mounting the differential brackets directly to the engine, we take advantage of the many benefits provided by a direct load path. The entire FSAE car is designed around the engine. This allows us to take advantage of the strength of the engine while minimizing structural components in the frame
  - If we mount the differential brackets to the frame, a small amount of distortion could cause the differential housing to bind or introduce misalignments that could cause damage. Additionally, tight tolerances can be held when machining aluminum brackets to mount directly off precision mounting points on the engine. It would be very difficult to maintain tight tolerances for bearing alignment in pieces made of welded sheet steel.
  - There are many factors outside of the load path that contribute to the mounting position. The choice of a different style differential, the chain tensioning method, interferences caused by the sprocket and chain and the manufacturing capabilities all play a role in the final output of the drivetrain system.

Source: https://dspace.mit.edu/bitstream/handle/1721.1/36702/77550024-MIT.pdf

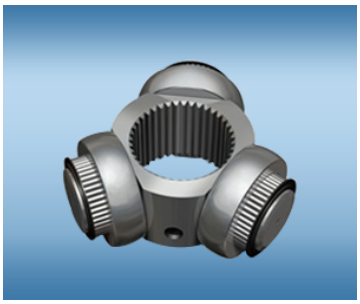
Halfshafts

- **What is the purpose of the halfshafts?**

- A half shaft is essentially a drive axle, and it's so named because it does half of the job, extending from a transaxle or differential to one of the wheels. Its twin on the other side completes the set.
- They connect the spool to the spindle. They are steel shafts with bearing tripods at both ends.

- **What forces act on them? Provide a free body diagram.**
  - 

Forces acting on a half shaft
  - Source: http://thecartech.com/subjects/design/axle_shafts_design.htm

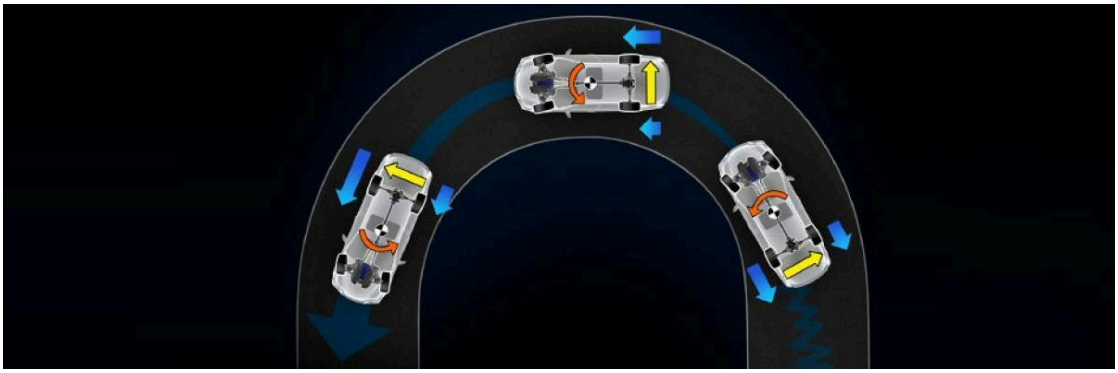
- **How do they interface with the rest of the system?**
  - The axle shaft (half shaft) transmits the drive from the differential sun wheel to the rear hub. The arrangement of a simple rear axle can be seen in the FBD figure above, the road wheel attached to the end of the half shaft, which in turn is supported by a bearing located in the axle casing. The diagram illustrates the forces acting on the rear axle assembly under different operating conditions.
  - Types of axles
    - Axle shafts are divided into three main groups depending on the stresses to which the shaft is subjected:
      - Semi-floating
      - Three-quarter floating
      - Fully floating
- **What effect do the tripod bearings have on the inputted torque?**
- Source: https://hartfordtechnologies.com/bearing-parts-manufacturer/tripot-cv-joint-trunnion/
  - 

- A tripod ball CV (constant velocity) joint is used at the inboard end of a driveshaft or half shaft.
- It transfers uniform torque and constant speed, despite changes in angle, enabling consistent transmission of power. A tripot joint assembly has needle bearing-shaped rollers that are mounted to a three-part yoke. These fit inside a cup with matching grooves, which attach to the differential.

Differential

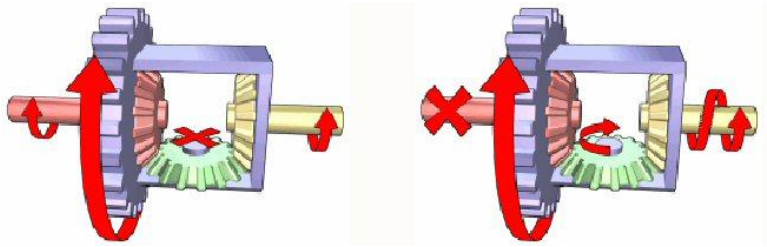
Source:

- https://www.matfoundrygroup.com/News%20and%20Blog/Types_of_Differential_and_How_They_Work
- https://www.matfoundrygroup.com/News%20and%20Blog/Types_of_Differential_and_How_They_Work

- **What is the purpose of the differential?**
  - In simple terms, the differential allows the powered-wheels to turn at different speeds.
  - Responsible for maintaining speeds of wheels, useful when making a corner turn - power being distributed to the turning wheels as illustrated in the diagram.
  - 
  - The yellow arrow highlights the torque transfer occurring through the corner, generated by the artificial resistance being exerted by the TVD on the outside wheel. This allows for greater acceleration out of the corner while the car's turning ability is increased.
  - Without a differential (as in a solid axle) both wheels are forced to rotate at the same speed, scrubbing one tire under cornering. Performance can be improved through the use of a differential, which allows the wheels to rotate at different speeds

- **List the types of differentials and how they function.**

  - **Open Differential:**
    - A differential in its most basic form comprises two halves of an axle with a gear on each end, connected together by a third gear making up three sides of a square. This is usually supplemented by a fourth gear for added strength, completing the square.

- 
- **Disadvantage**
  - Open differentials don't work well on uneven or slippery surfaces because the engine torque is transmitted to the wheel with the least resistance (a.k.a. “traction”). If the tire is off the ground or on ice, it spins freely and the vehicle is unable to move.
  - Source: https://www.eaton.com/us/en-us/products/differentials-traction-control/open-differential.html

- **Locked Differential:**
  - A differential that provides a locked axle condition. Can be manual or automatic, as in hydraulic locking differential, NoSPIN, Detroit Locker and ELocker differentials.
  - The locked or locking differential is a variant found on some vehicles, primarily those that go off road. It is essentially an open differential with the ability to be locked in place to create a fixed axle instead of an independent one. This can happen manually or electronically depending on technology in the vehicle.
  - The benefit of a locked differential is it is able to gain a considerably greater amount of traction than an open differential. Because the torque is not equally split 50/50 it can channel more torque to the wheel that has the better traction - and is not limited by the lower traction of the other wheel at any given moment.
  - **Disadvantages**
    - Because they do not operate as smoothly as standard differentials, automatic locking differentials are often responsible for increased tire wear. Some older automatic locking differentials are known for making a clicking or banging noise when locking and unlocking as the vehicle negotiates turns.

- **Welded/Spool Differential:**
  - Welded differentials are essentially the same as a locked differential, only it has been permanently welded from an open differential into a fixed axle (also known as a spool diff.) This is usually only done in specific circumstances where the characteristics of the locked diff/fixed axle,

which makes it easier to keep both wheels spinning simultaneously, are desirable – for example, in cars meant for drifting.
        - **Disadvantages:**
            -

    - **Limited Slip Differential:**
        - LSD's work to combine the benefits of Open and Locked differentials through a more complicated system.

    - **Torsen Differential:**
        - The Torsen (Torque – Sensing) differential employs the use of some clever gearing to produce the same effect as a limited Slip Differential without the need for clutches or fluid resistance.
        - 

    - **Active Differential:**
        - Very similar to a limited slip differential, the active differential still employs mechanisms to provide the resistance needed to transfer torque from one side to another - but rather than relying on purely mechanical force, these clutches can be electronically activated.

    - **Torque Vectoring Differential:**
        - The TVD takes this electronically enhanced system even further by using it to manipulate the angle, or vector, of the vehicle in and out of the turns by encouraging specific wheels to receive more torque at key moments - improving cornering performance.

- **How does the differential interface with the rest of the system?**
    - The differential is necessary when the vehicle turns, making the wheel that is traveling around the outside of the turning curve roll farther and faster than the other.
    - A differential is a system that transmits an engine's torque to the wheels. The differential takes the power from the engine and splits it, allowing the wheels to spin at different speeds. ... Turn it around a corner and you'll have no issues, as each wheel is able to turn independently from the other.

    - As we're sure you can imagine: the entire differential mechanism has to cope with a huge amount of force which is just one reason why those components are made from the strongest materials possible. Not straws and milk bottle caps.
    - Differentials need to be extremely durable.

Chain Guard

Source:

- https://www.fsaeonline.com/cdsweb/gen/DocumentResources.aspx
- https://www.pinkbike.com/news/To-The-Point-Chain-Guides-2013.html
- GFR Drivetrain Design 2016

- **What is the purpose of the chain guard?**
    - A chain guard, also known as "chain case" or "gear case," is a protection for the differential chain, in the case of FSAE mechanics. Typically made of solid steel or aluminum.
    - Its sole purpose is to stop debris from directly impacting from the rolling chain.

- **How is it mounted to the system?**
    - The rear piece mounts to the diffuser and goes up and through the hardpoint that has the opening for the left drivetrain mount. The interior piece of the chain guard mounts to the engine's stock chain guard and the inside of the chassis (through a hole made in a hardpoint).

Figure 12: Left side spool mount (the sprocket and chain guard can be seen as well)

- **What are the sizing limitations for a steel chain guard? An aluminum one?**

  <u>According to the FSAE 2021 Rules</u>

  Steel chain guard
  - Be made of 2.66 mm (0.105 inch) minimum thickness steel (no alternatives are allowed)
  - Have a minimum width equal to three times the width of the chain
  - Be centered on the centerline of the chain
  - Remain aligned with the chain under all conditions

  Aluminum chain guard
  - Be made from 3.0 mm minimum thickness aluminum alloy 6061-T6
  - Have a minimum width that is equal to 1.7 times the width of the belt.
  - Be centered on the centerline of the belt
  - Remain aligned with the belt under all conditions.

Phase 3: Current State of System

Go through the design binder of your subsystem and schedule a meeting with the subsystem lead to understand the current state of the system, the immediate tasks that need to be finished, and the timeline the system is following. Document below important facts/decisions previously made, pictures of CAD, questions you may have based on the system, and any other important lessons learned or information for your subsystem lead.

Goal: To get up to speed with the system and find out what has been done and what is left to do. Put effort into trying to understand why specific design decisions were made.

Terms to Lookup:

- Meaning of FoS spectrum
- Bearing Pressure

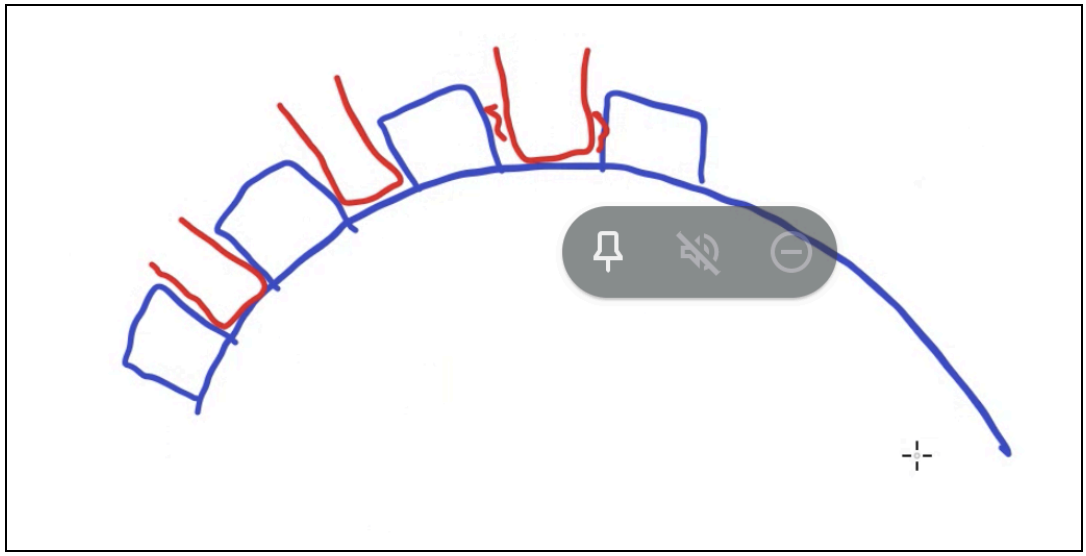
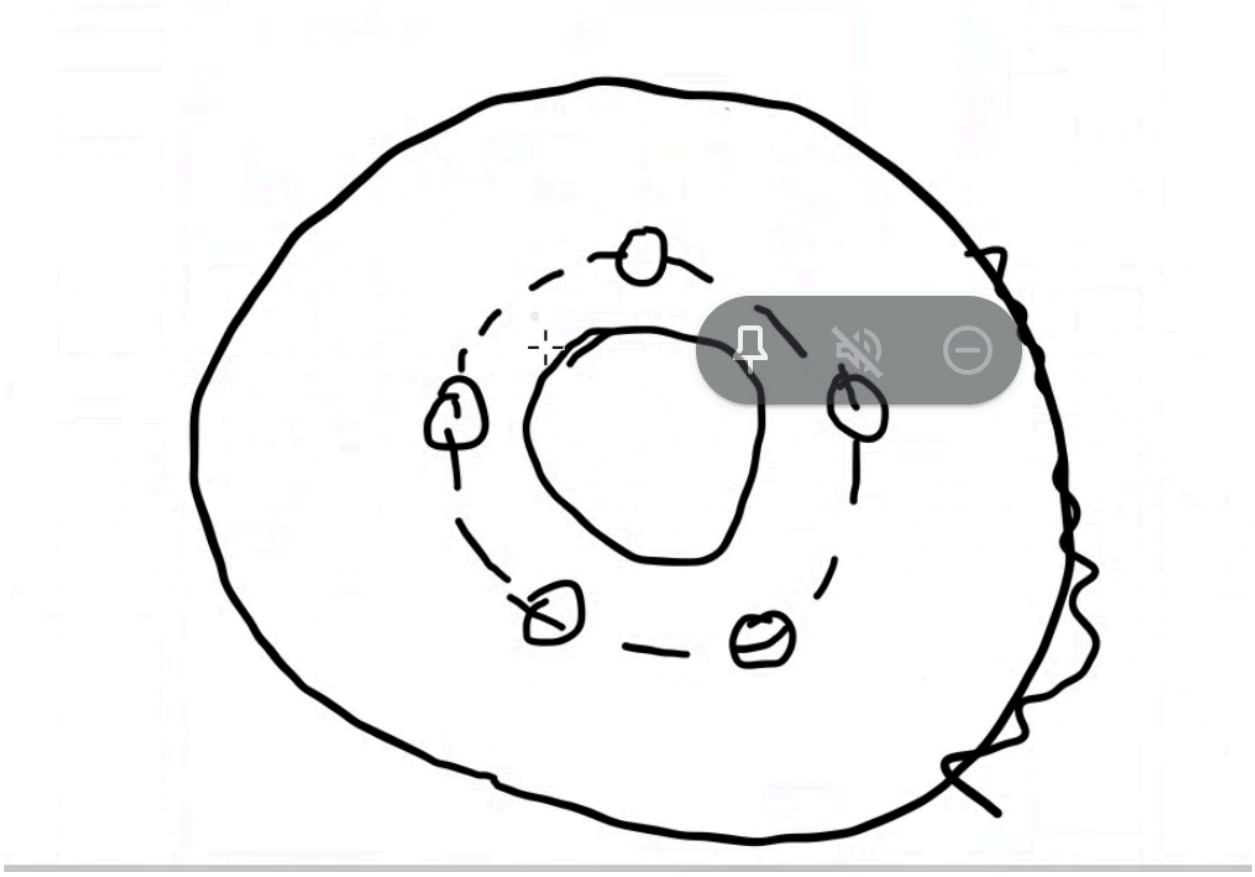
To do:

- Message Erica about Solidworks License

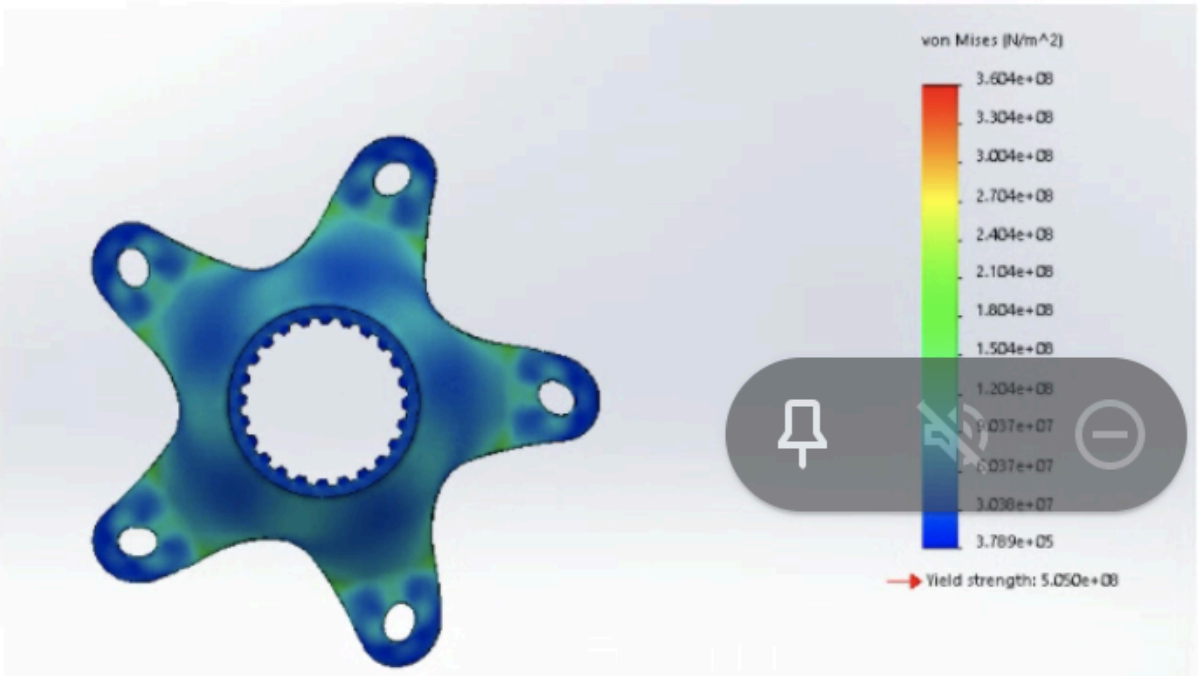
Sprocket carrier:

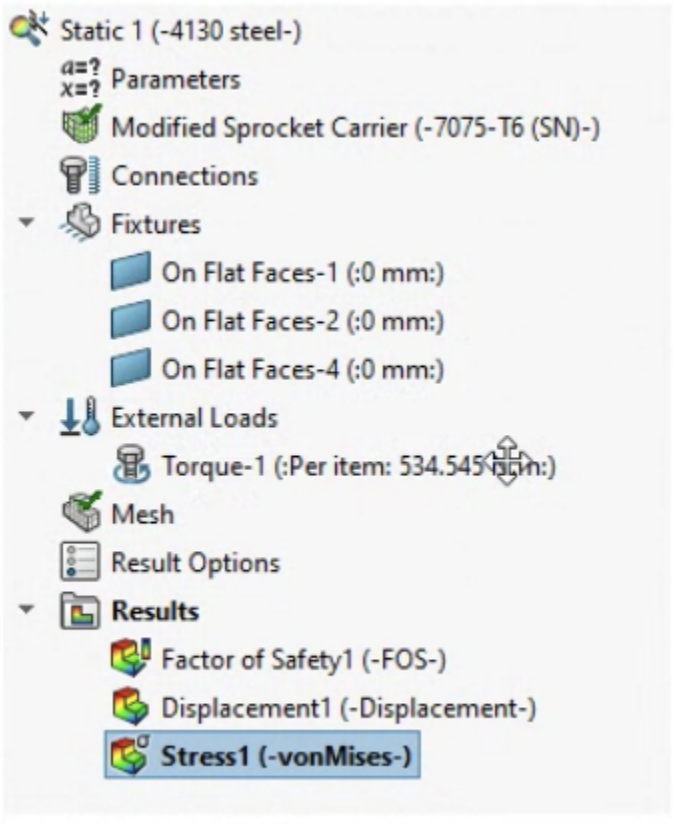
- ***Goal: Withstand torque Over the season***
- Material: 775 T6 aluminum

- Requires most work
- Designing
    - Modify existing design
- Load case
- Combustion car
    - Final Drive
    - Torque delivery
- Withstand torque of 120 Nm, reliability and safety
- Spline issue
    - Machine new sprocket till manufacturing
    - Movement to the differential splines
    - Sort of play going around

- 
- 
- New one has 5 spoke holes, to accommodate the sprocket.
- Spoke - bits that stick out from the center.
- Final Drive: 4.483Nm

-



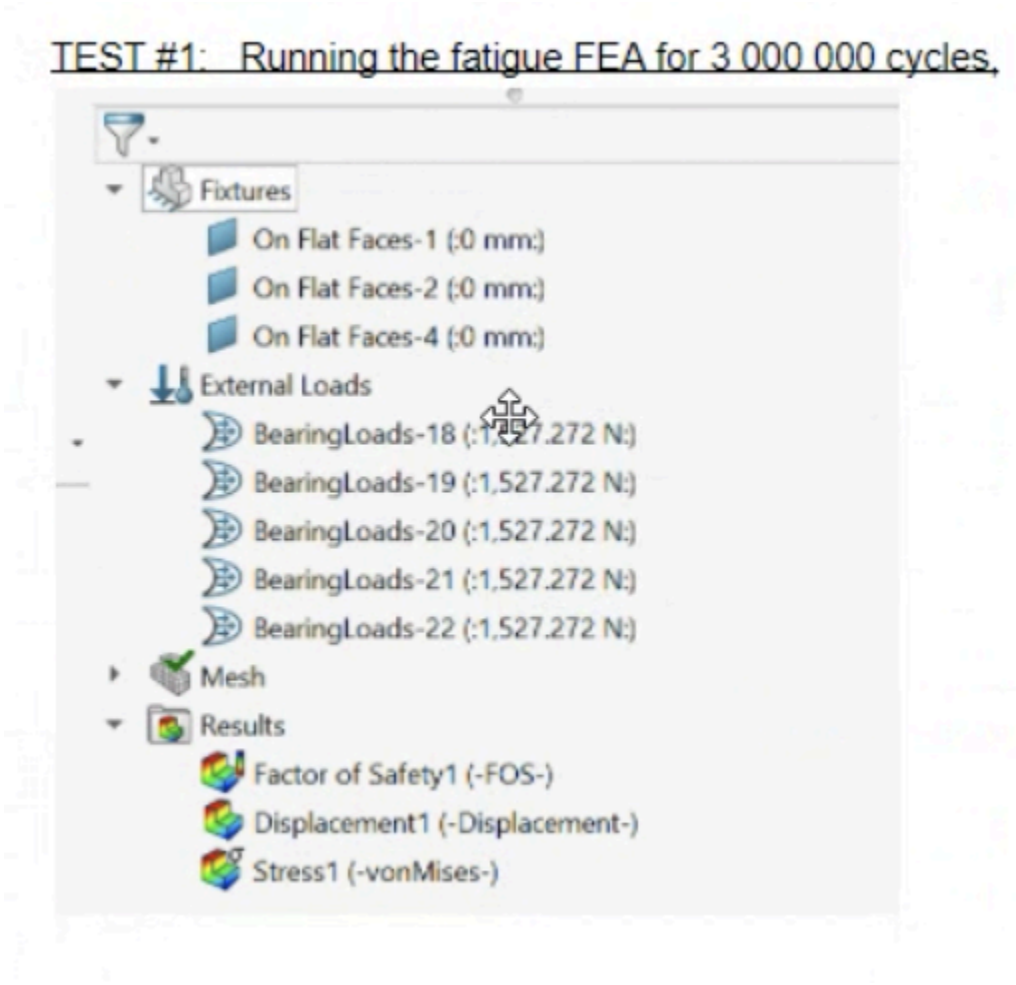


- 1.401 - Decent Fos
- **Factor reduced:**
  - 1.4 without spline

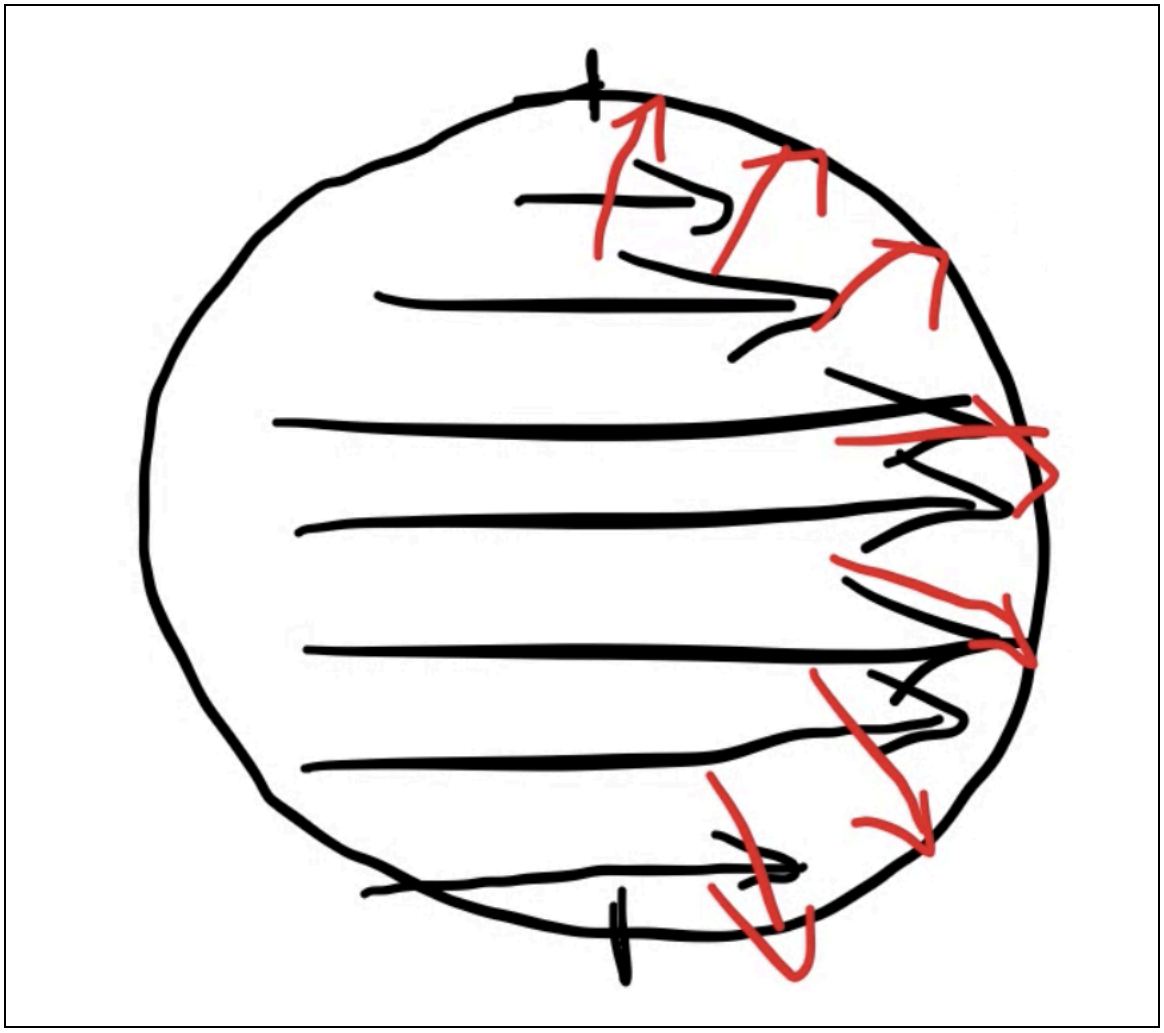
- 1.004 with the spline

Terms:

- Slippage: Wheels spin in a way like power slides. Exceeds to provide friction to drive on the road.



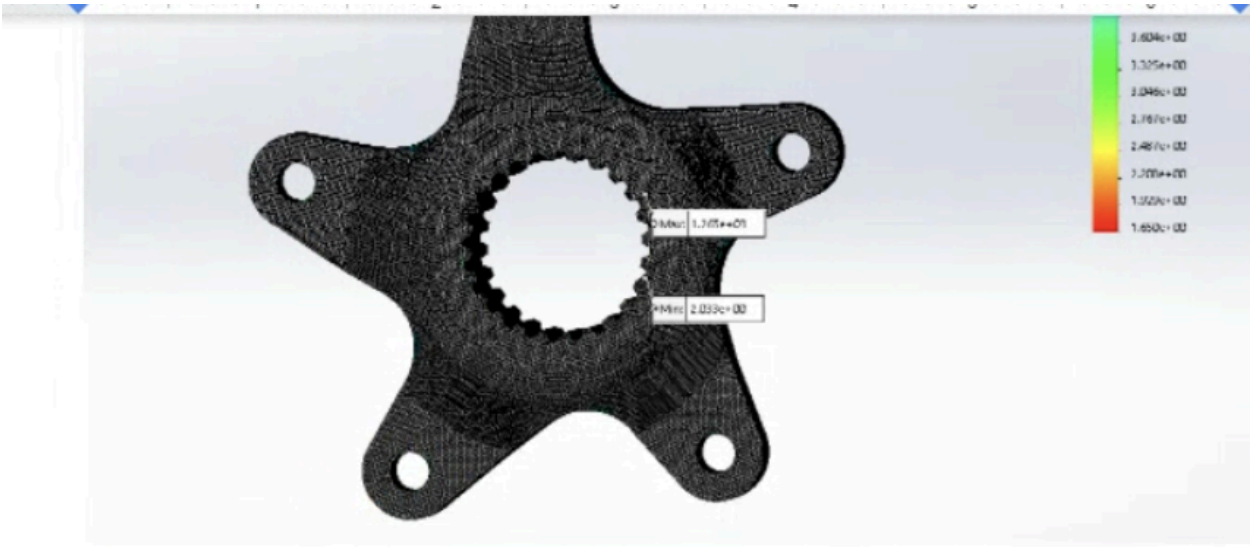
- Introduced those loads instead of the center.
- Bearing Load: Enables force on curved surface.



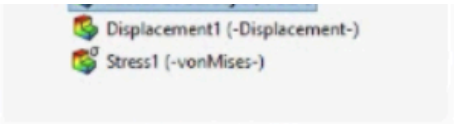
Replicates bolt force
Pull the chain
What will happen: create a moment around a sprocket carrier. It's on a moment arm.

Going in one direction would give Realistic FEA Setup.

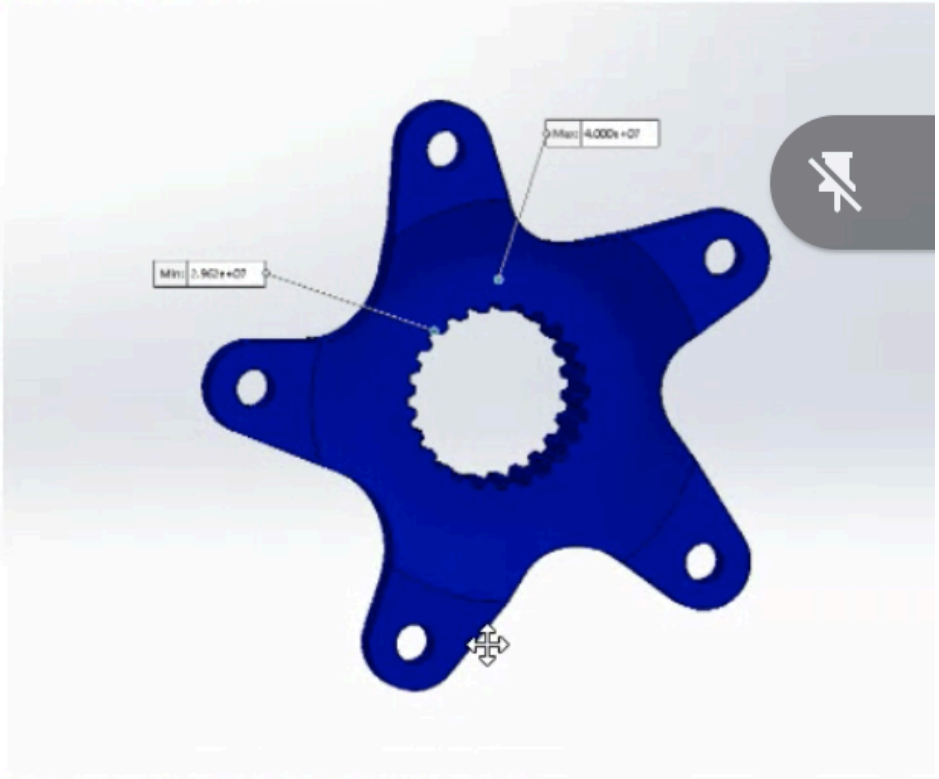
After multiple iterations and setup changes: (RIGHT NOW)



Minimum FOS of 2.033



With 4000000 cycles:



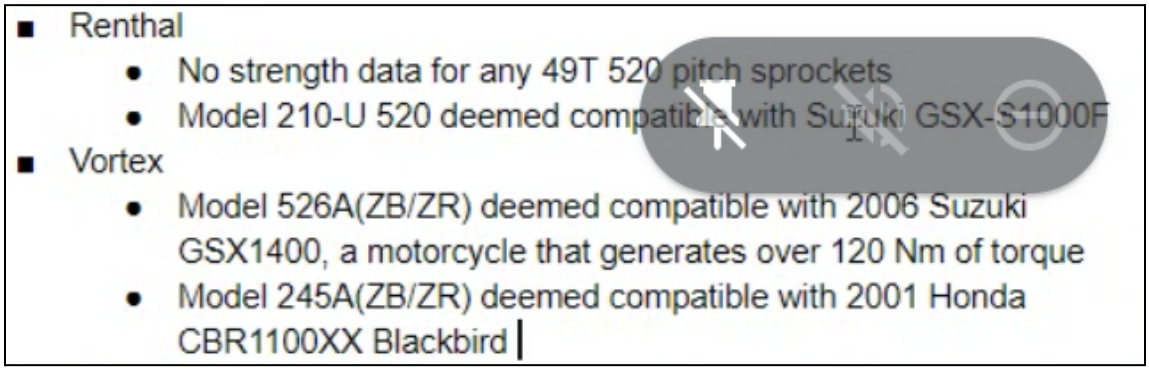
Minimum fatigue life of 29.62 million cycles

SPROCKET

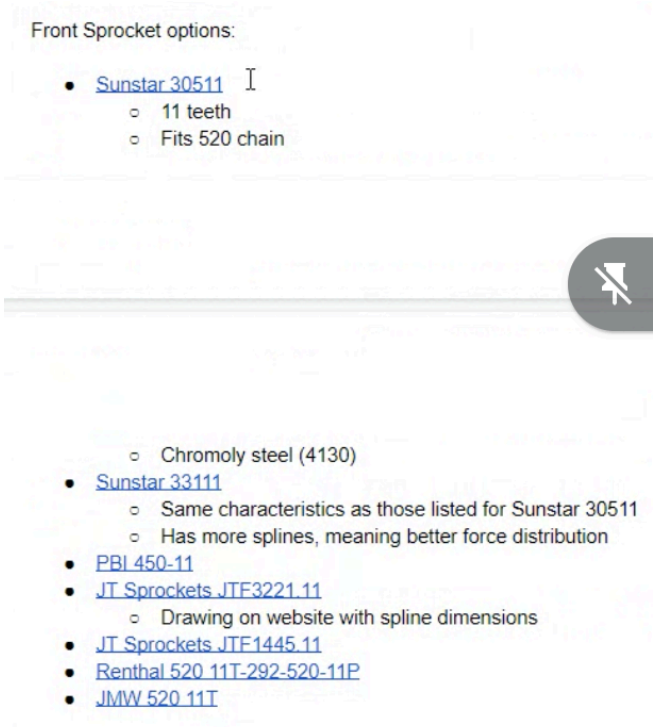
- **Goal: Withstand 120 Nm Torque generated by engine motor.**

Rear

- What he did:
  - Examples of Motorcycles that generate this much of torque
  - Website that sells sprockets: vortexracing; Entered the name of the bike.



Front



-

- Couldn't enter a bike that produce this torque:

HALFSHAFT

- Acquire - Procure shaft from RCV (automotive component company)
- 

DIFF

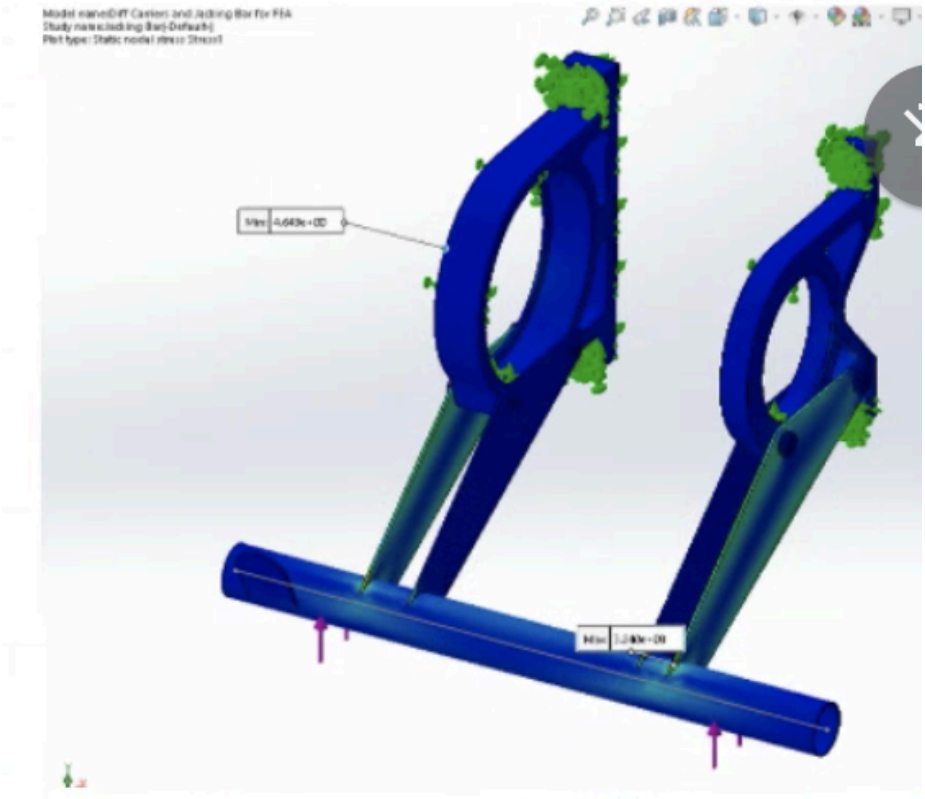
- Same Drexler design as last year

Tensioning

- As per the scope of work, the diff carriers will remain the same. As such

JACKING BAR

- Produces a jack to hook on to and lift the car up - Servicing.



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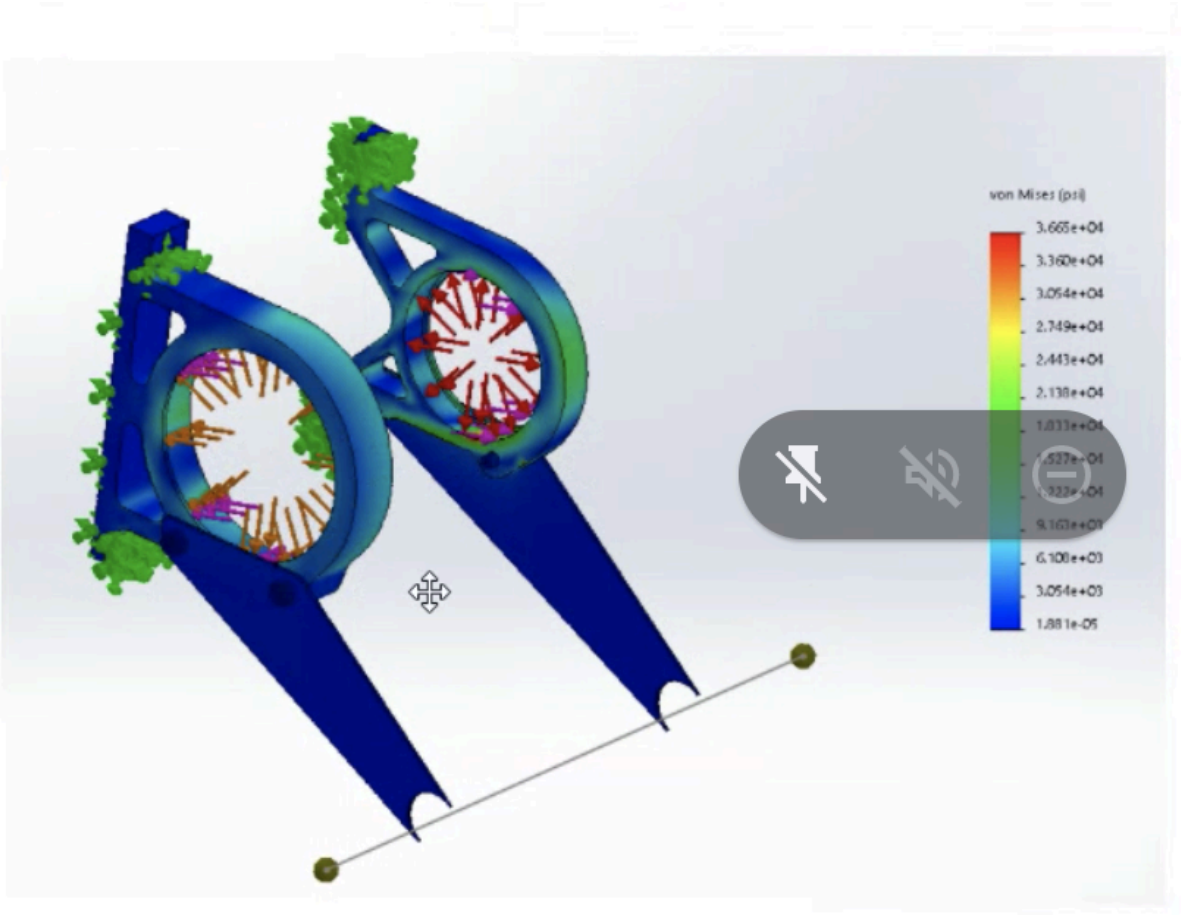
- FoS: Weight of car (Rear Distribution)

  Min stress: 4.649 Pa, Max stress: 3.24e8 Pa

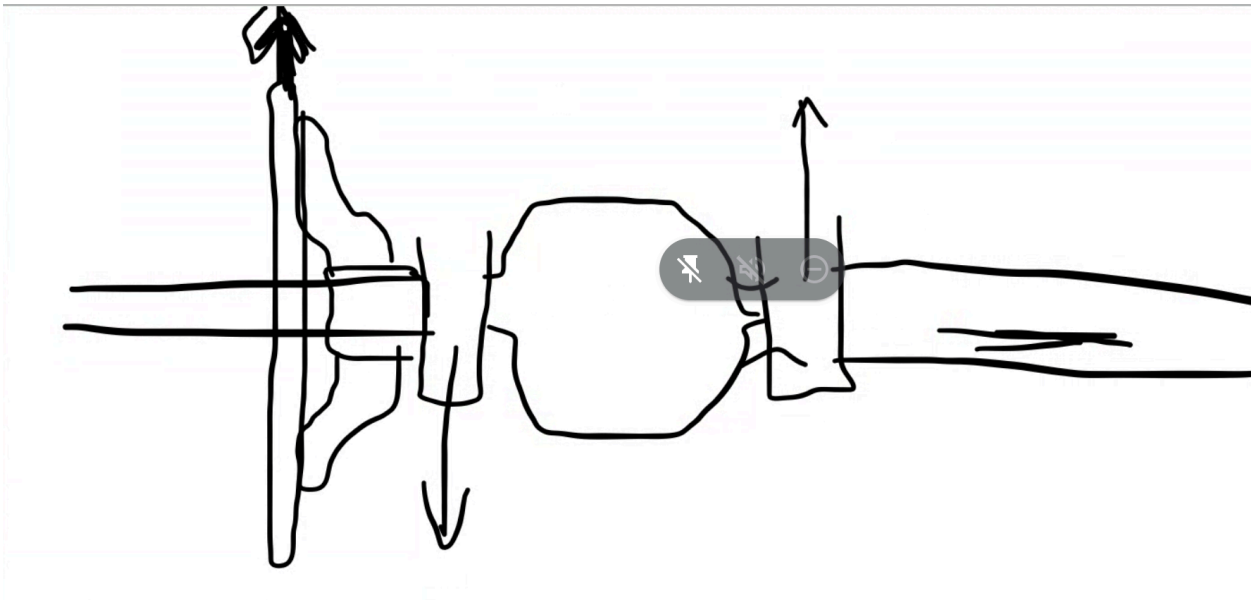
-

- Satisfactory

DIFF CARRIERS



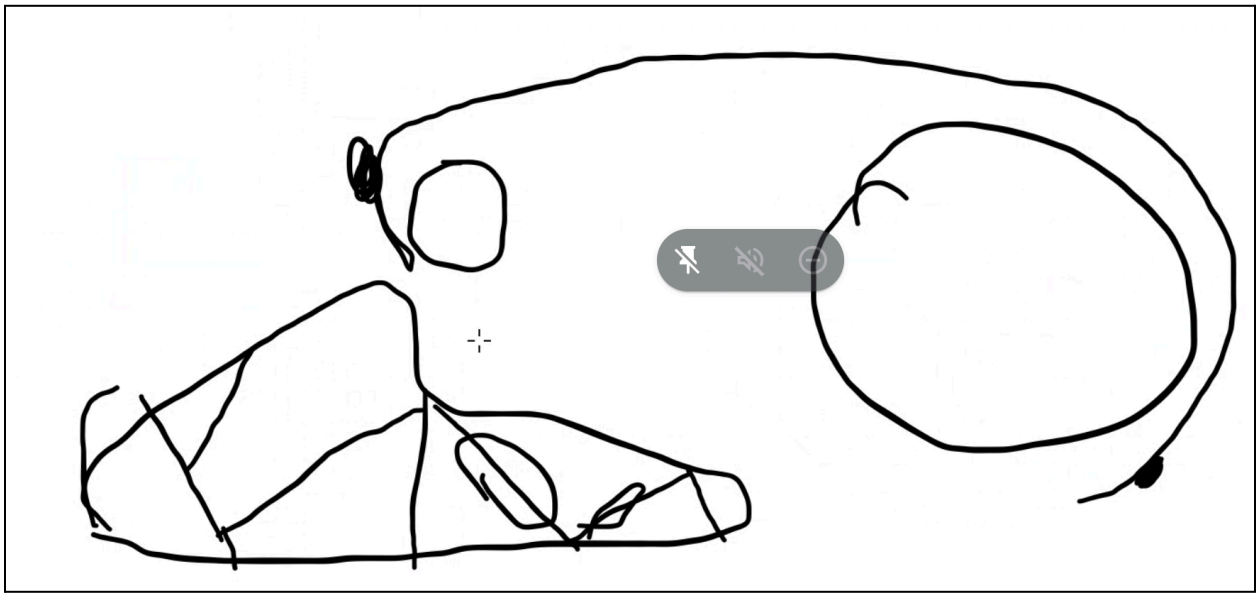
-
- Bearing Load introduced for diff carriers
- Pink Arrows: Bearing Loads - Come from the load the chain has on the system.



Going in opposite direction: Reactionary Loads

Goal of the Diff Carrier Purpose: Hold the diff in place.

CHAIN GUARD

- Focus on Frame
- 
- Frame Member: Chassis Tube
- Which frame member to attach to.

Focus:

- Front Sprocket and Shaft
- Finalizing Chassis to locate mounting point front for Chain Guard
- FEA for Diff Carriers