SHIV NADAR

INSTITUTION OF EMINENCE DEEMED TO BE UNIVERSITY

DELHI NCR

robotyantriki

17th November 2022

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TABLE OF CONTENT

STEERING

Steering Systems –

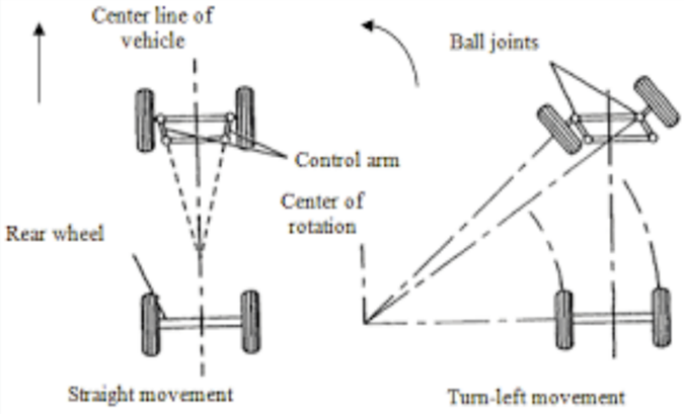
Ackerman Steering System

Pros:

- The inner wheel turns more than the outer wheel to effectively steer the vehicle without any slip.

Cons:

- The additional linkages in the steering/power train are just more parts that could fail.
- The intention of Ackermann geometry is to avoid the need for tires to slip sideways when following the path around a curve.
- The geometrical solution to this is for all wheels to have their axles arranged as radii of circles with a common center point.



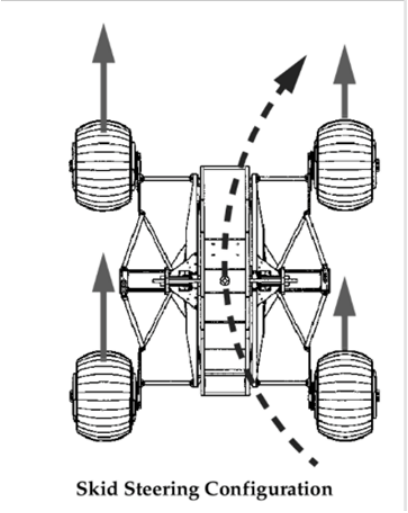
Skid Steering System

Pros:

- The advantage of a skid-steer is increased traction and no "caster wheel effect".

Cons:

- Skidding has some disadvantages including tire/track wear.
- Moving in a straight line requires the wheels on each side to be turning at the same speed, which can be difficult to achieve.


Skid Steering Configuration

Bars for operating the rover-

<u>Drop Bars</u>

Pros:

- More hand positions- Drop bars offer 3 distinct hand positions: on the hoods, on the bars, and in the drops.
- Drops offer an aerodynamic advantage.
- Drops can fit through more narrow spots in traffic- Standard drop bars measure around 40-46 cm in width. Typical flat bars measure 58-60 cm wide. On average, drop bars are around 20 cm narrower than flat bars.

Cons:

- Parts are more expensive.
- The brake levers are not as easily accessible- If you need to stop quickly in an emergency, you may need to move your hands to a different handlebar position in order to use the brakes.
- Drop bars don't offer as much control as flat bars- Because drop bars are so narrow you just can't get the leverage to quickly or accurately turn them like you can with flat bars
- Visibility can be poor with drop bars.

<u>Flat bars</u>

Pros:

- Flat bars give you much better control- Because flat bars are wider, they give you better leverage.
- Flat bar components are cheaper
- Changing cables is easy- The cables and cable housings are all exposed. There is no bar tape to deal with.

Cons:

- Flat bars offer only one hand position- This is the biggest drawback to flat bars
- Flat bars are less aerodynamic- Flat bars put you in an upright riding position. In this position, your chest acts like a parachute and creates a lot of drag.
- Flat bars require a wider gap to pass through.

Reasons for using Side Handlebars –

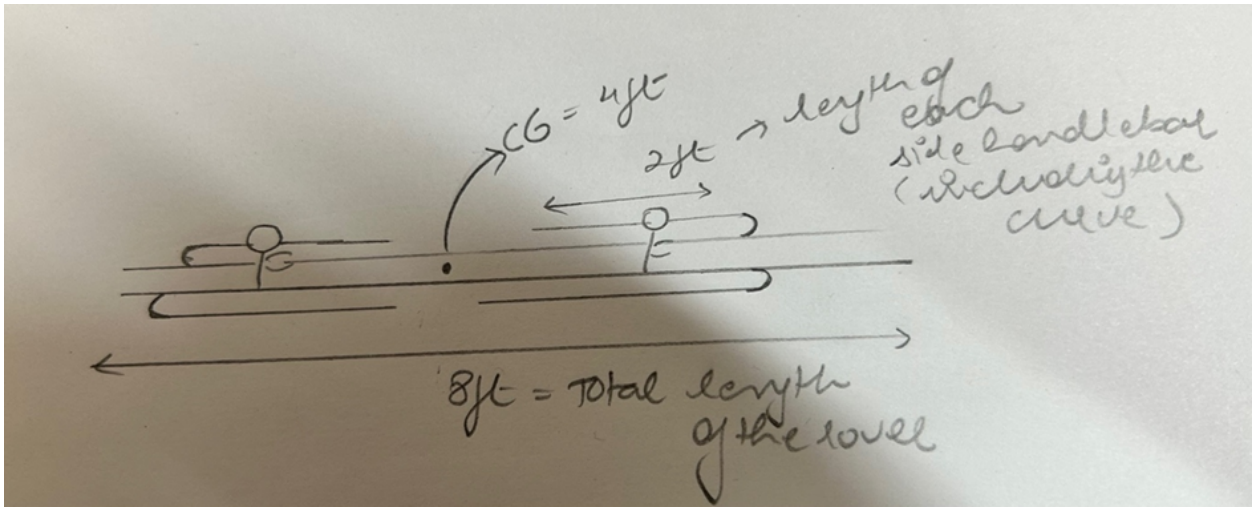
- Better grip for both the drivers with both hands.
- Better control of directions.
- Does not affect the folding mechanism of the rover.
- Fits right in place according to the dimensions of the rover.

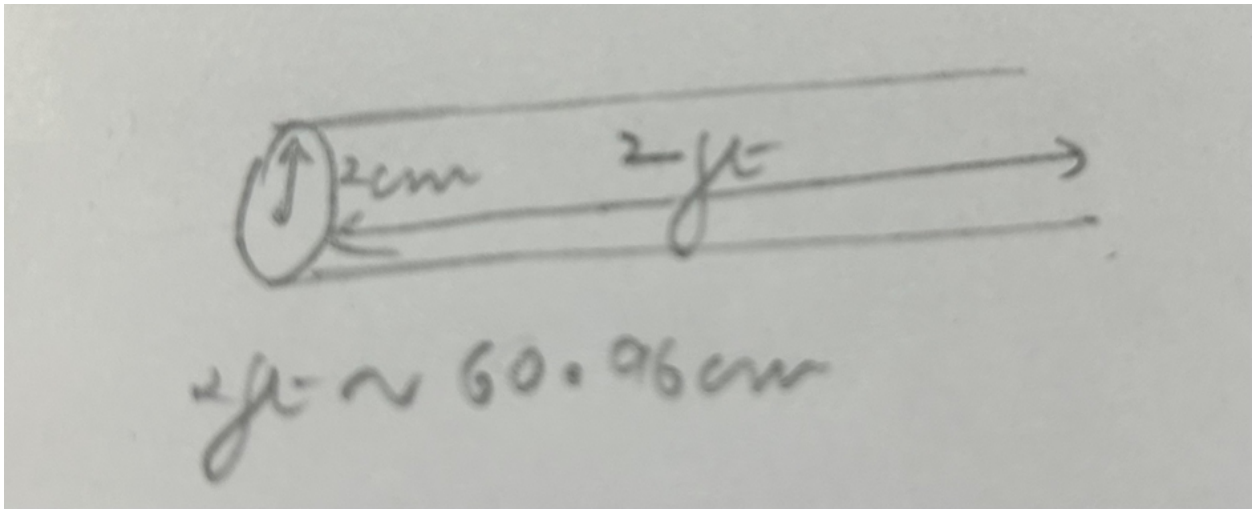
Material for the side handlebar- Aluminum

Reason-

- Aluminium handlebars are extremely durable, and if they do fail, it's not typically a catastrophic failure. When you do crash your bike, aluminum stands up to scrapes and scratches a little bit better than carbon. All carbon bars use a painted finish while a majority of aluminum bars use a shot-peened and anodized finish that is much more durable.
- While carbon handlebars are very expensive, aluminum bars will cost you much less. You could buy two sets of alloy handlebars for the cost of one carbon bar.
- Our rover has its main body made from aluminum; welding would be easy if the material used is the same.

Approximate Calculations-



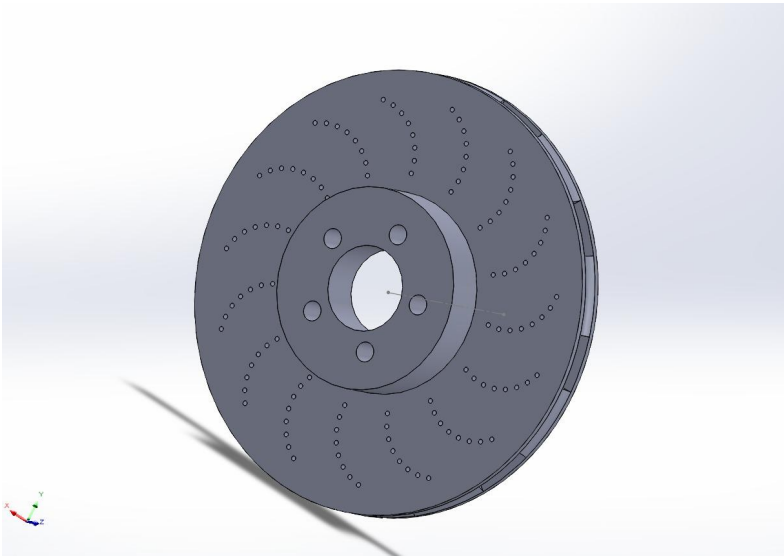


- Density of Aluminum = 2.7 g/cm^3
- Area of each side handlebar = (π/4) x d^2 = (π/4) x 4^2 = 12.56 cm^2
- Volume of each side handlebar = $\pi r^2 h$ = π x 2^2 x 60.96 = 765.65 cm^3
- Weight of each side handlebar = density x volume = 2.067255 kg
- Cost of 1kg Aluminum = 140 INR
- Weight of 4 side handlebars = 2.067255 x 4 = 8.26902 kg
- Cost of 4 side handlebars = 8.26902 x 140 = 1,157 INR ($14)

BRAKES

Drum brakes-

- Requires less force to apply brakes.
- They are cost-effective.
- Transmitting time is less.
- No fluid is used.
- It is self-locking.
- They have poor anti-fade characteristics.
- These brakes have 20 to 30 percent more weight than disk brakes.
- Low ventilation property.
- Disk Brakes-
- Less effort and produces greater braking force
- Good heat dissipation



- Easy

  Installation
- fluid is used
- is more efficient and when we stop it stops fast as compared to the drum

  brake. Better ventilation properties.

We will use disc brakes in our rover on all front and rear wheels.

1. **Hydraulic Disc Brakes**

Use both pads to create more effective frictional force. Less everyday wear and tear.

Better modulation & stopping power.

2. **Mechanical Disc Brakes**
   - Comparatively less modulation and stopping power. Overall, hydraulic disc brakes are superior in terms of performance and efficiency because of the reduced friction by not having a mechanical cable and reducing wear and tear of cables.

Reasons to use Hydraulic disc brakes at the front and rear wheels.

The stopping of vehicles results in more weight on front tires and axles. Now since the disc brakes are more efficient and can bear more weight, they are used on front wheels. While climbing the slopes, we will also need to stop the vehicle from moving backward, so at the rear wheels, we will also use disk brakes. We discard the other options of breaking because either they are heavier or very complex to implement into a rover.

As the design of our rover needs brakes for both the drivers sitting at the back and the front, we will be using the brakes in all four tires according to the dual braking system.

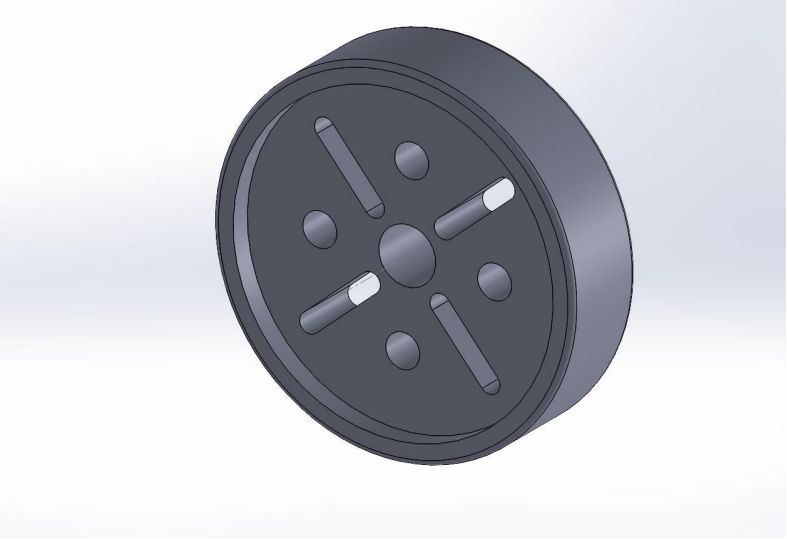
In a split or dual braking system, pressure to the brakes is applied to the wheels on separate lines carrying a special Hydraulic fluid.

There are two basic types of split braking systems, viz. a front, and rear split system and the second is known as a diagonal split braking system.

WHEELS-

Materials that can be used for rim:-

- Aluminum
- Stainless steel
- Moulded rubber
- Plastic
- Wood



Aluminum :- It's extremely machineable and light weight. Extremely expensive machining tools needed to make wheels out of a solid block of it.

Stainless steel :- It is extremely heavy but also machineable. Welding stainless steel is extremely easy, but the weight constraints remove it from the running.

Moulded rubber :- Extremely durable and lightweight. It gets deformed easily. Small quantities of tyres cannot be manufactured using this method as it is only suitable for mass manufacturing.

In conclusion Aluminum is the most suitable material for our tyre rims as it's extreme.

CHASSIS-

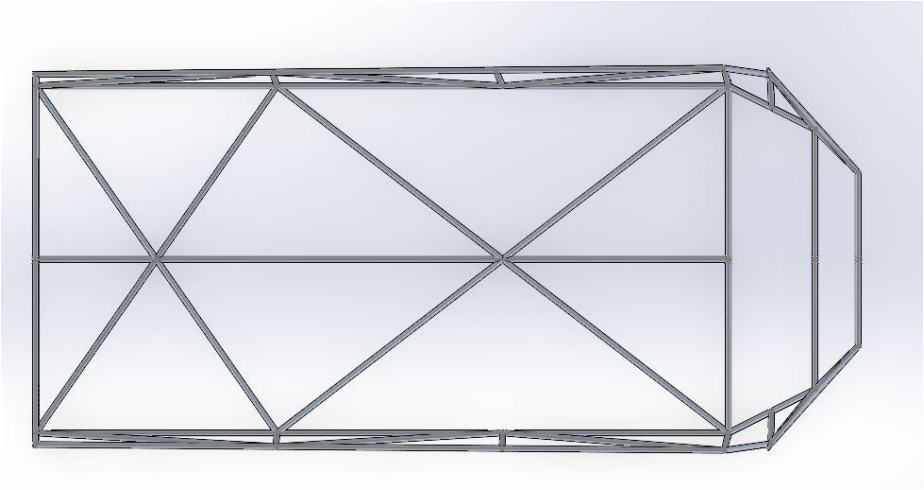
Rover is a vehicle for exploring the surface of a planet or moon. For, this competition, it is supposed to be designed to four non-pneumatic tires and be capable of traversing on the land of other planets.

The chassis of a rover is a skeleton structure that supports systems such as suspension, steering, and the powertrain. For this reason, the chassis of an all-terrain is designed by considering factors such as the safety of the driver, ease of manufacturing, sustainability, compactness, lightweight and ergonomics design.

The special requirements of a rover, like the need of better stability and safety is done by providing a stable chassis structure, which is the basic load bearing framework of the rover.

Some factors which must be kept in mind while designing the chassis is -

- Human ergonomics
- Manufacturing
- Strength of materials
- Factor of safety



The design and establishment process of the chassis involves various considerations, namely material selection, cross section determination, chassis design, and finite element analysis. One of the critical design decisions that enhance the reliability, safety, and performance of any vehicle structure is the material choosing.

The material selection for the chassis is Grade 2024-T3 is the most common high-strength aluminium alloy. It is often considered aircraft quality. It has excellent fatigue resistance even though its corrosion resistance is lower than that of 6061.

Material Grade	**Aluminium Alloy Grade 2024-T3**	**Stainless Steel Grade 304**	**Magnesium AZ91D-F**	**Aluminium 7075-O**	**Titanium Ti-6Al-4V(grade 5)**
Density	**2.78g/cc**	**8.00 g/cc**	**1.81 g/cc**	**2.81 g/cc**	**4.43 g/cc**
Poisson ratio	**0.33**	**0.29**	**0.35**	**0.33**	**0.342**

Elongation	**20%**	**70 %**	**3.0%**	**17 %**	**14 %**
Shear Modulus	**4060 ksi**	**11200 ksi**	**2470 ksi**	**3900 ksi**	**6380 ksi**
Tensile Strength	**41000 psi**	**73200 psi**	**33400 psi**	**33000 psi**	**138000 psi**

The legs of the rover, which will have the maximum load will be constructed with stainless steel AISI 4130 as it has the most tensile strength and a density of 7.85 g/cm^3 which will help us in keeping the rover strong and durable to bear the weight.

Approximate weight of legs = 3.993 kg

if the size of each leg is 50 cm and provided, we are using pipes of outer diameter 3 cm and internal diameter 2.4cm

The body of the rover will be made of Aluminium Alloy Grade 2024-T3 because it has a density of 2.78 g/cc and will consist of about 70% of the rover, helping us in making it lightweight and durable for use. 41000 psi is just enough for the body to handle the weight of the drivers and any obstacle we will face.

Approximate weight of chassis=12.8 kg

provided we are using pipes of outer diameter 3 cm and internal diameter 2.8cm.

The gearbox and mechanisms will be made of Stainless-Steel Grade 304 as it is an economically feasible option. Furthermore, it has one of the highest tensile strengths, which we require as we cannot afford for such an essential component of the rover to fail.

Approximate weight of the drivetrain = 10 kg

DRIVETRAIN-

We researched various types of ways to power the vehicle manually, where our primary focus was not to use chain and sprocket system ,as it was not encouraged in the competition.

Belt Drive System-

While researching about belt drives, we found that there are several types of belt drives like: -

- Round Belt
- Flat Belt
- V shaped belt
- Toothed belt
- Link belt

For using the belt drive systems, its-

Advantages	**Disadvantages**
• Cost-effective • Simple to use • No need for parallel shaft • Come with jam protection • Load fluctuations are shock absorbed • Reduce noise and vibrations	• It is not possible at places with high torque applications • Not compact • Greater wear and tear • Inflict heavy load on shafts • Angular velocity not constant • Operating temperature at -35° to 85°C • Velocity not constant due to V-belt slip

Gear Drive System-

For gear systems and types of them, their advantages, and disadvantages were as follows:-

Advanatge	**Disadvantages**
· They are non-slip drives · Deliver high transmission efficiency · Ideal for low, medium, and high-power transmission · More compact compared to belts and chains · They can transmit motion over small centre distance of shafts	· Cannot be used for shafts with large centre distances · Not ideal for large velocities · Need regular lubrication · Multiple gears raise machine overall weight · They have no flexibility

Overall, after thorough comparison, consideration and as per our need, we concluded that **gearboxes** were better than any other way to power our rover.

The parts required in building the drive train will be bevel gears, gearbox, and differentials. There are two modes of transmission in this proposed model of drivetrain. One is high rpm and moderate torque associated with the front axle and the other is low rpm and high torque associated with the rear axle. The rear wheels have larger wheel diameter than the front wheels resulting in more grip and torque, whereas the front wheels will be relatively

smaller in size resulting in more rpm helping in traversing the course faster.

The type of gear which will be used in this configuration is a hypoid gear as it suits the requirements and will not slip when in use. Also, this is the best option when it comes to fold the chassis.

For the front axle, we will attach the pedals to the gearbox which further will be connected to the differential which will be connected to the wheels. For rear axle, we have planned to attach the pedals to the gearbox. This gearbox will be connected to the differential at the back via shaft. This differential will be further connected to the wheels. The rear gearbox will have a higher gear-ratio as it is required to give more torque whereas the front gearbox will have a lower gear-ratio to attain a higher rpm.

SUSPENSION-

Air shocks-

An air suspension system is a style of vehicle suspension that's powered by an electric pump or compressor that pumps air into flexible bellows that are typically made out of a textile-reinforced type of rubber.

What Is Electronically Controlled Air Suspension?

According to the company now known as Dunlop Systems and Components, at the start of the 1990s, Dunlop developed and installed the Electronic Controlled Air Suspension (ECAS) system on the 1993 Range Rover Classic and again on the Range Rover P38A. The United Kingdom-based company developed the ECAS to include several key features:

- Vulcanized, heavy-duty rubber air springs at each of the vehicle's wheels
- An air compressor in the vehicle's trunk or under the hood of the vehicle

- A storage tank for compressed air, which allows you to store air at around an average of 150 PSI
- Valve blocks which direct air to the four springs from the storage reservoir through a set of solenoids, valves, and o-rings
- ECAS computer that communicates between the vehicle's main computer to calculate where to direct air pressure
- Air pipes connecting from the storage tank to the air springs that channel the flow of air throughout the suspension system
- A desiccant-filled drier canister to keep the internal recesses of the system dry

The Benefits and Drawbacks of Air Suspension Systems

More driver comfort due to the reduction in noise, harshness, and vibration on the road that can cause driver discomfort and fatigue

- Less wear and tear on the suspension system due to reduced harshness and vibration of heavy-duty driving
- Trailers last longer with air suspension because the system components don't take on as much vibration
- Air suspension reduces the tendency of short-wheelbase trucks to bounce over rougher roads and terrain when the vehicle is empty
- Air suspension improves the ride height based on the load weight and a vehicle's speed

- Higher corner speeds due to air suspension being better suited to the surface of the road

Air shocks are not viable for our use case due to needing an external compressor to inflate the rubber bellows and also due to the fact that they require an external electrical power source to power the compressor.

Leaf springs-

What are leaf springs?

Leaf springs are a basic form of suspension made up of layers of steel of varying sizes sandwiched one upon the other. Most leaf spring setups are formed into an elliptical shape through the use of spring steel which has properties that allow it to flex as pressure is added at either end but then return to its original position through a damping process. The steel is generally cut into rectangular sections and then once held together by metal clips at either end and a large bolt through the center of the leafs. It is then mounted to the axle of the vehicle using large U-bolts, securing the suspension in place.

Advantages

- Due to the sheer amount of metal layered together, leaf springs offer a large amount of support between the wheels, axles, and the car's chassis. They can take huge vertical loads being applied to them due to their tight-knit structure, hence why heavy-duty industries still use them. Vertical loading is also distributed throughout the length of the leaf spring rather than acutely through a small spring and damper, which can potentially create a concentrated force too large for the suspension to handle.

Disadvantages

- A big downside of leaf setups is they aren't brilliant when it comes to suspension tuning. In racing and performance car applications, it is vital to be able to manipulate a suspension setup for the driving conditions and for different driving styles, something that is much easier nowadays through adjustable coilovers. This lack of adjustability of leaf setups is emphasized by the fact that the ends of the leaf springs are attached to the chassis, which leaves very little scope for shortening or lengthening of the leafs. Adjustments can therefore only really be made through the strength and flexibility of the material used to make up the leaf springs.

- Leafs also allow very few directions of motion and are only really designed to move vertically, while a spring and damper combination can be manipulated into a much larger range of motion. Leaf springs are firmly clamped together and bolted to the chassis as well as clipped to the axle, thus giving little to no scope for any other direction of motion which can lead to heavy wear on the joints and connections holding the setup together.
- This connection with a live rear axle can cause comical dynamic characteristics in a car when compared to a more modern independent suspension setup, something that older Mustangs are famous for. The rear axle will simply bounce around high-speed corners as the suspension and axle are forced to move around together when a modern damped system would add much more composure to the driving experience.
- In comparison with a helical spring, leaf springs are generally much stiffer simply down to the steel construction and the tight package that they are bolted and clamped into. Ride comfort is therefore not a feature of vehicles that use leaf springs which made their popularity decrease dramatically after proper dampers were introduced in the 1970s to everyday cars in a cost-effective manner.

Coilover Suspension

A Coilover suspension (also called a screw suspension) refers to a suspension that allows individual adjustment of the ground clearance. This is done by means of a screw thread on the suspension strut. For this reason, a car with a Coilover suspension can also be raised or lowered quickly and without tools by private individuals.

In addition to flexible lowering, most Coilover suspensions also have other adjustment options. In addition to the hardness, the driver can often also adjust the rebound or compression damping.

In this way, Coilover suspension allows optimal adjustment to personal preferences, the vehicle setup, the track, and external conditions.

Types of Coilover suspensions:

- **Coilovers with manual lowering**

The classic. Thanks to the screw thread, an individual lowering, usually between 20 and 70 mm, can be adjusted by hand.

Suitable for: Tuning beginners and drivers who are looking for individual lowering and sporty handling, but use their vehicle for the most part in everyday situations.

- **Coilovers with adjustable rebound and compression damping**

With adjustable rebound and compression damping, the suspension can be adapted to personal preferences in handling, to special track conditions, or also to vehicle characteristics, such as weight or tire characteristics. This makes it easier for the driver to adapt the suspension to his or her taste.

Suitable for: Performance-oriented drivers and tuning enthusiasts who place great value on sportiness in their vehicles.

High-performance coilovers for club and racing sports

Coilovers feature independently adjustable compression and rebound damping settings, as well as full-length ride height adjustment. This suspension system is ideal for enthusiasts desiring excellent handling when they participate in occasional track days, weekend race events, club circuit races, or less aggressive road competitions. This kit allows for adjustable damping setups for daily driving without sacrificing ride comfort. The external reservoir allows for increased oil capacity to dissipate heat superiorly, which enables you to use the coilovers for a long period of time without failure and improves the performance & handling of your vehicle substantially.

Electronically adjustable coilovers

More and more premium vehicles today are equipped with an adaptive suspension system. These systems offer a continuous adjustment of the damper rate to the road conditions. This is done with the help of speed, wheel force, and engine control sensors.

At the touch of a button, the driver can usually switch between a sport or comfort setting. This feature is particularly popular with regular track visitors because it allows comfortable travel and an unfiltered racetrack experience to be combined in one car. Suitable for: Drivers who own a vehicle with an active shock absorber system (such as Porsche PASM) but do not want to do without maximum lowering and improved driving dynamics.

Conclusion: Keeping all the pros and cons of 3 types of suspension systems, We have decided to use Coilover suspension as they are extremely cost-effective and can be tailored to our requirements. They also don't need any external equipment to function.

SAMPLE COLLECTION-

- **Selfie stick and cup :** This method is extremely ingenious and allows for an extremely simplistic design while being lightweight and compact. The only problem with this method is that it can't be manoeuvred into tight spaces and can not go into areas that are not completely straight.

- **Electronic vacuum pump with single use sample collection containers:**This allows us to collect samples without putting in any effort from the driver as all the work is done by an electric motor in the pump. The problem with this design is that it is extremely difficult to prevent cross contamination.

- **Large syringe**: This method consists of us using a large syringe in combination with vinyl tubing and a fishing rod. The large syringe creates a vacuum strong enough to collect the sample while also doubling as the sample collection container. The fishing rod is used to reach spaces that are too high for the driver to reach on his own.

In conclusion the most effective method for sample collection is the large syringe method as it is the lost space efficient, effective and lightweight.

Personnel Hazard Analysis

S No.	Phase	Types of Hazards	Hazards	Preventive Actions
		Metal welding	● Health issues related to eyes, skin.	● Respiratory protective equipment. ● Fire resistant clothing.
1.	Manfucaturing	Metal Cutting	● Exposure to metal fumes and to ultraviolet radiation.	● Use face shield. ● Safety glasses are required.
		Drilling	● Includes respiratory problems.	● Don’t wear loose clothing or gloves. ● Safety gloves, googles, work boots.
		Bending	● Operator's hands being caught and drawn into the	● Install a safety clip or retainer . ● Wear clothing that fits well.

			in-running nip, can lead to injuries.	
		Riveting	● May suffer eye injuries caused by flying pieces of metal.	● Use proper safety tools.
		Shearing and Forming	● Injuries includes crushing of tissues, breaking of bones.	● Use of correct tools, safety gloves, proper equipment.
		Machining	● Risk of injuries, noise, vibrations.	● Wear safety glasses or goggles.
2.	Excursion	Mechanical Moving Parts	● Can cause shock, fractures, dislocations if encountered worker's body	● Wear appropriate personal protective equipment.
		Impact	● A person can strike an object or can be struck by a moving object	● Wear appropriate safety gears
		Crush or Pinch	● An object or machine can crush or pinch the body.	● Never walk away from a machine that is turned on or coasting

		Breaking of a part	• Sharp edges can cause cuts and other injuries, people can be struck	• Wear seat belt, avoid distractions

DFMAE-

NASA HERC DFMEA | **Date: November 2022**

Name of the College: Shiv Nadar Institute of Emminence | **Faculty Advisor: Mr Aakash Sinha**

Team Member(s) Responsible: Rudransh Gupta

MODEL YEAR(s) / VEHICLE(s) : | DFMEA date - 4th November-22

ITEM / Function	Potential Failure Mode	Potential Effect(s) of Failures	Potential Cause(s)/Mechanism(s) of Failures	Current Design Control	Recommended Action(s)	Action Results
						Action Taken
brake rotor disks	Over Heating, Damage due to unforeseen road conditions, Driving with damaged rotor pads	Insufficent braking performance, Thermal stresses which may lead to deformation of the rotors, Insufficent friction leading to longer stopping periods	Improper material selection, Rotor getting wet	Thermal analysis of the rotors and performing sufficent tests for different conditions	Periodic checking and replacement Proper selection of material Effective analysis and testing	Periodic checking and replacement Proper selection of material Effective analysis and testing
ball joints	Shearing of threads bending of joints	breakage of suspension links	Improper size/length selection external debris	Inspection of joints and the subassembly	Proper selection of joints inspection of joints and the subassembly before installing	Inspection of joints and the subassembly before installing
suspension mountings/brackets	Misalignment of the joints, worn out bushings	More movemment of arms, Poor handling or loose steering	excessive loads than what was the mount originally designed for, Impact loads	Proper CAE analysis and designing accordingly	Proper design based on the CAE analysis, appropriate selection of materials	Proper selection and stiffness calculation of spring
	Breaking of mountings	Loss of control over the vehicle				testing of springs in the vehicle before implementation
springs	Breakage of the spring	vehice giving out on either one side or all sides Vehicle touching/rubbing against the terrain	Corrosion, decarburization Low yield stress of the spring	Proper material selection Proper testing of the springs	Appropriate testing of the springs before implementation	proper CAE analysis and physically checking the dampers
	Permanent deformation of the spring	Sagging of the vehicle, lower ground clearance	Insufficent spring stiffness			
	Bending/Breaking of dampers, dampers getting stiff					
suspension arms	breakage	Trouble in controlling the vehicle Wheel could fall off	Poor material selection,Inaccurate d	Ensure proper mounting by inspection and acco	Accurate designing according to har	Accurate mounting as per hardpoints and CAE analysis
steering column	there should be no slipping of gears	unable to steer the vehicle	`	proper material selection	CAE analysis	Periodic checking and replacement Proper selection of material Effective analysis and testing
gearbox	Should be able to withstand shifting of gea	the transmission will get stuck , hence making the vehicle unable to move	Not sufficient application of grease onto the gears	proper material selection and CAE analysis	proper material selection	Periodic checking and replacement, effective analysis and testing