Turning System

Hydraulic Tilting Wheels

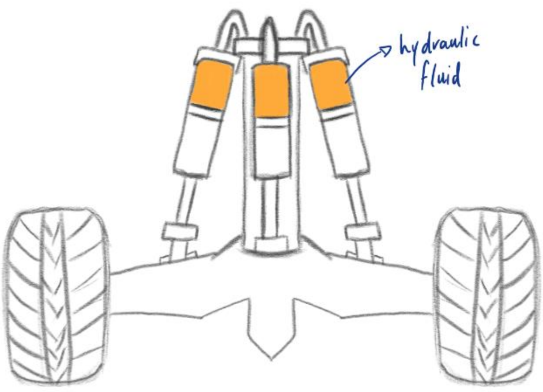

Figure 1: Concept Design 1

A hydraulic tilting system shown in Figure 1 uses three hydraulic cylinders to generate tilt. Alongside tilting this system also helps assist the suspension, via its middle cylinder. This concept aims to tilt the wheels of the vehicle using hydraulic systems.

Advantages

This system tilts all three wheels, this could mean the time taken to reach the ±45° would be well within the given regulations. Having three hydraulic actuators also means the suspension of the vehicle would be rigid and have a sustainable life expectancy.

Disadvantages

As mentioned previously the concept aims to tilt both the rear wheels, this leaves the vehicle more vulnerable to toppling as the front end of the vehicle is also designed to tilt. If this concept design is implemented this could limit the angle of tilt due to safety reasons. Another disadvantage is regarding the manufacturing costs. Having three hydraulic cylinders could lead to a potentially higher production cost. This would be an unnecessary expense specially if it could be easily replaced by a suspension spring (ideally replacing the central hydraulic cylinder). Considering the compatibility with the drive train, the engine would optimally be placed in front of this tilting system. This could lead to issues like restricting access to the engine for maintenance.

Quadrilateral Tilting Wheels

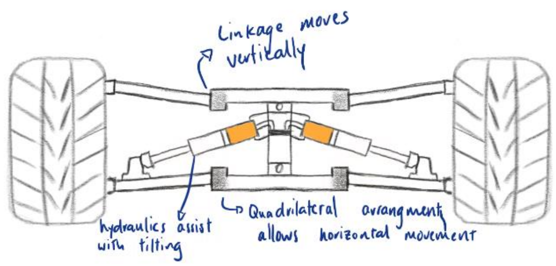

Figure 2: Concept Design 2

A quadrilateral tilting system shown in Figure 2, allows tilting of the wheels as well as the vertical movement of the entire vehicle. This concept is like the previous one as this also tilts the rear and front wheels as well as the chassis. Two hydraulic cylinders are placed horizontally to precisely tilt the vehicle to the requirements.

Advantages

With respect to the engine, this system occupies less space, which in turn allows easy access to the engine bay for maintenance. As discussed previously, if all three wheels tilt, the vehicle could reach maximum tilt in a shorter period, therefore outperforming the regulations.

Disadvantages

A great disadvantage of this concept is that, like the previous one it tilts the front and rear wheels alongside the chassis. This would in turn restrict the angle of tilt due to the dangers of toppling. Another disadvantage is that this mechanism is prone to scraping the ground on bumpy roads.

Unlike the last concept this one doesn't have a rigid support which holds the mechanism up, it relies solely on the wheels to keep it upright. If for example if the vehicle goes over a speed breaker at a higher speed the mechanism could be damaged due to a lower alignment.

Chassis Tilting System

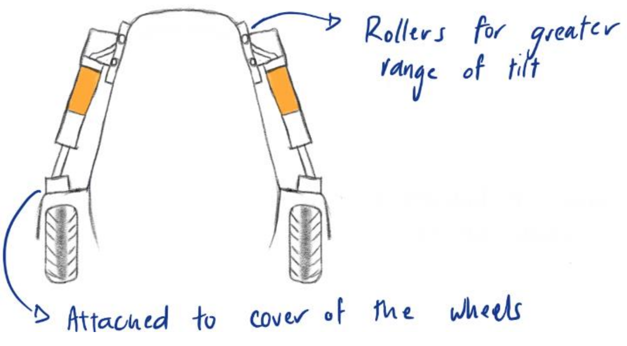

Figure 3: Concept Design 3

Concept Design 3 slightly coincides with the first hydraulic tilting system discussed. This version however is attached to the chassis as compared to the wheels. The mechanism operates two hydraulic cylinders located on top of the cover of the wheel as shown in the sketch below. Unlike the quadrilateral tilting chassis system, this mechanism doesn't affect the shape of the chassis.

Advantages

An advantage of this concept is again the mechanism is connected to the chassis rather than the wheels. This would increase the stability of the entire vehicle. Alongside stability, this concept's compatibility with the engine spacing and shape of the chassis is greater than all the previous concepts discussed.

Disadvantages

A disadvantage of this system its arrangement. The biggest issue we would face is where the other hydraulic components such as valves and fluid tank would be placed.

Hydraulic Tilting Chassis (Quadrilateral Arrangement)

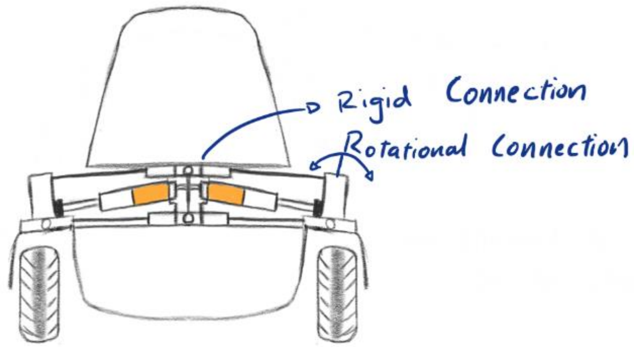

Figure 4: Concept Design 4

Figure 4 shows concept 4 which is like the previous one, however instead of connecting to the wheels this system rigidly connects to the chassis. Two hydraulic cylinders are used and located horizontally within the system. The entire is submerged within the chassis as shown on the left. This connects to the blocks above the wheel casing which allow rotational motion, producing tilt.

Advantages

This improved version of the previous system targets to move only the chassis rather than the rear wheels which leads to more stability. Due to the encased style of this concept there is no accountability for scraping.

Disadvantages

Due to the arrangement of this mechanism the biggest disadvantage is that its fully submerged within the chassis. This means less space for the engine, transmission, storage etc.

Compatibility

Drivetrain

The drivetrain and the turning system are related closely as their placement depends upon each other. The engine is the largest component of the drive train, and therefore its placement is crucial for the rest of the subsystems. While coming up with the first two concept designs (Figure 1 & Figure 2), I imagined the engine to fit in front of the turning system. The arrangement of the first concept shows the engine is completely blocked off by it and therefore inaccessible for maintenance. For the second concept the engine is only partially blocked, however it would still pose an issue for maintenance. The third concept design considers the space and the maintenance requirements and is optimally placed out of the engine bay's way. The fourth subsystem is designed with the intention to have the engine below it. However, it's quite demanding in terms of space which would leave millimetres of clearance for the engine.

Brakes

All the concept designs for the brakes suggest that system is fitted on the insides of the wheels. This would be ideal for most of the concepts discussed as neither the disc brakes nor the drum brakes require much space outside of the wheel. Concept Design 1 requires two shafts to be attached to the insides of the rear wheels. Therefore, this could potentially interfere with the braking system making it a poor option. The second concept (Figure 2) also has attachments with the wheel leading to potential interference with the braking system. The third and fourth concepts (Figure 3 & Figure 4) have virtually no connection with the insides of the wheel, meaning either of them would make an optimal choice.

Chassis

Most of the concepts of the turning system depend heavily on the shape of the chassis. This cuts down some of poor designs and highlights the best ones. Concept Design 1 requires a chassis which is built tall. The overall design would have a higher centre of gravity, which could lead to restrictions on the maximum tilt due to the dynamics of the vehicle. The arrangement of Concept Design 2 requires a chassis which is broad from the bottom. This could leave the entire vehicle more prone to scraping on uneven surfaces. Concept Design 3 requires the chassis to have a rigid casing on the wheels. No other requirements are necessary making it the least demanding concept. Concept Design 4 requires a lot of space within the chassis as its fully submerged in it. This leads to interior space and storage reductions.

Morphological Analysis

Subsystem	Concept 1	Concept 2	Concept 3	Concept 4
Turning System	Hydraulic Tilting Wheels (3 cylinders)	Hydraulic tilting wheels Quadrilateral arrangement (2 cylinders)	Hydraulic tilting Chassis (2 cylinders)	Hydraulic tilting chassis quadrilateral arrangement (2 cylinders)
Powertrain	Single disc dry friction clutch actuated by a cable + 1.4 litre Nissan Micra engine	Multi disk dry friction clutch actuated by a cable + Ducati 848 motorcycle engine	Single disc wet friction clutch actuated by hydraulics + Honda Civic 1.8L engine	Multi disc wet clutch actuated by hydraulics + 1000cc motorcycle engine

Chassis	Long + recumbent + canopy + side casing	High + Upright + sliding doors + interior storage	Low + upright + scissor doors + front storage	Low + Upright + convertible + interior storage
Brakes	3 disc brakes	3 drum brakes	2 disc brakes + 1 drum brake	2 drum brakes + 1 disc brake.

Table 1: Morphological Analysis

Table 1: Morphological Analysis shows the morphological analysis our team conducted. Highlighted in red are the concepts of each subsystem which are the most compatible with each other, as well as optimum in performing their individual functions.