Brainstorming & Concept Development

To arrive at an optimal suspension design I conducted some research and worked my way through sketches, before I started cad modelling. I divided the brainstorming into 2 sections to develop stage by stage. Firstly, to decide on the best shape of the suspension design afterwards to decide on the best approach for the differential system connecting the right and the left suspension together.

Shape of the suspension system

First, I worked on some rough sketches to see what the suspension can look like, I decided to research on 3 different shapes.

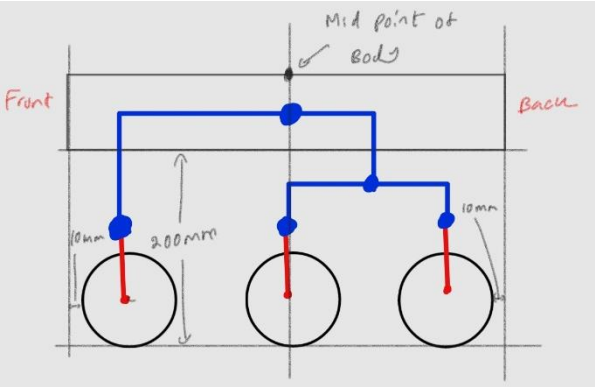

Figure 1: Square Rocker-Bogie Design

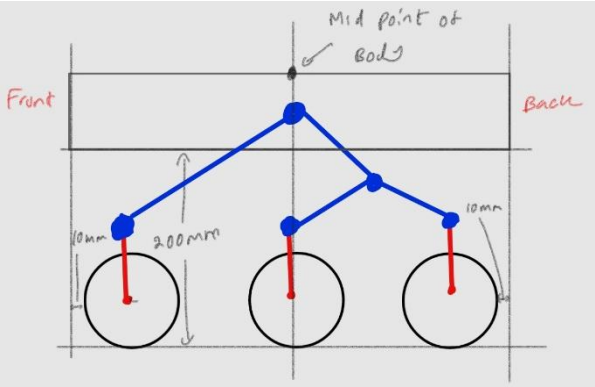

Figure 2: Straight Rocker-Bogie Design

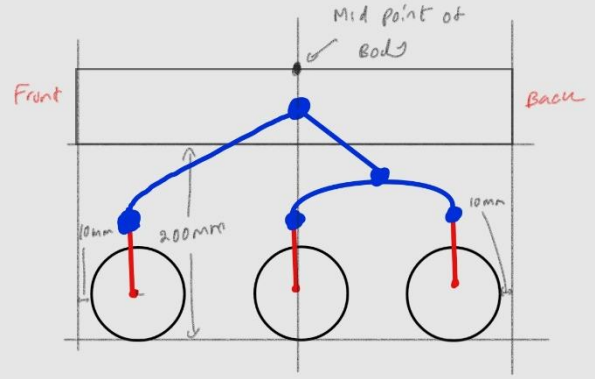

Figure 3: Curved Rocker-Bogie Design

Out of the above three sketches the “Straight Rocker-Bogie Design” appeared to be a weak design as there is more stress concentration at joints. Therefore, I worked on comparing the

remaining two designs to find out what might be the best option. Firstly, I listed the pros and cons as below;

Square Rocker-Bogie Design		Curved Rocker-Bogie Design	
Advantages	Disadvantages	Advantages	Disadvantages
Provides more articulation	Load distribution may be uneven	Load sharing between wheels is more balanced	Less independent wheel movement compared to the square design
Can handle uneven terrain with good adaptability	Higher chance of misalignment or wear at joints.	Easier to integrate with the body and drive system	Slightly less adaptable on very jagged terrain

Table 3: Comparison of Square and Curved Rocker-Bogie Design

After the comparison I decided that both suspension systems show equal level of relevance therefore I created the CAD model using the software SolidWorks 2025. I used a 20mm tubing design with thickness 3mm for both designs and found the mass using the material as Aluminium.

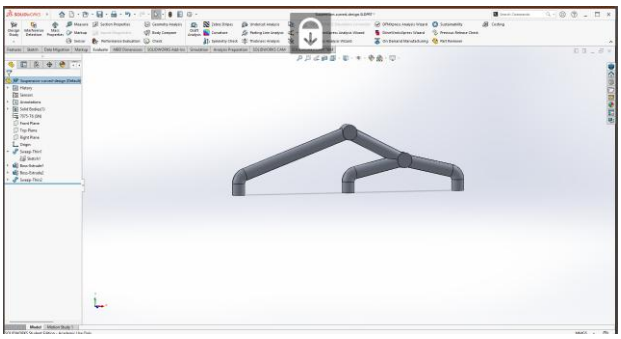

Figure 4: Curved Rocker-Bogie Design

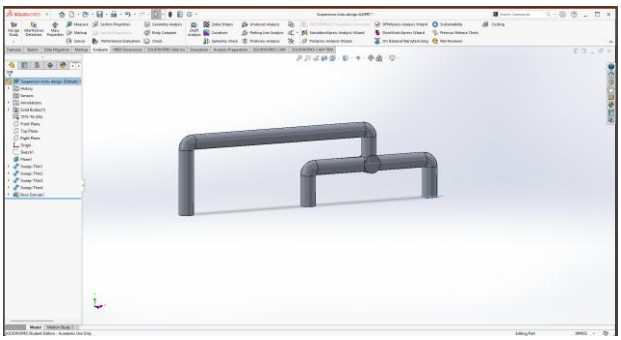

Figure 6: Square Rocker-Bogie Design

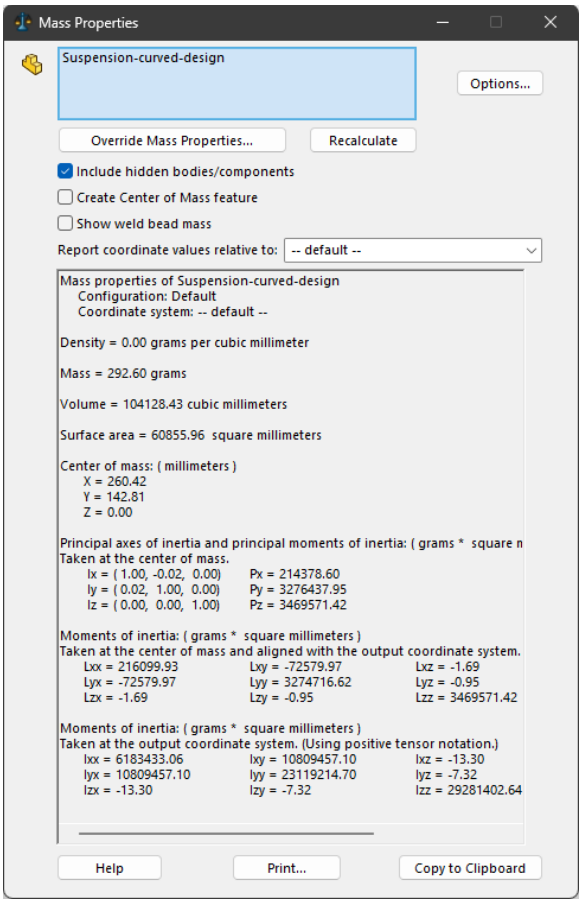

Figure 5: Mass Properties of Square Design

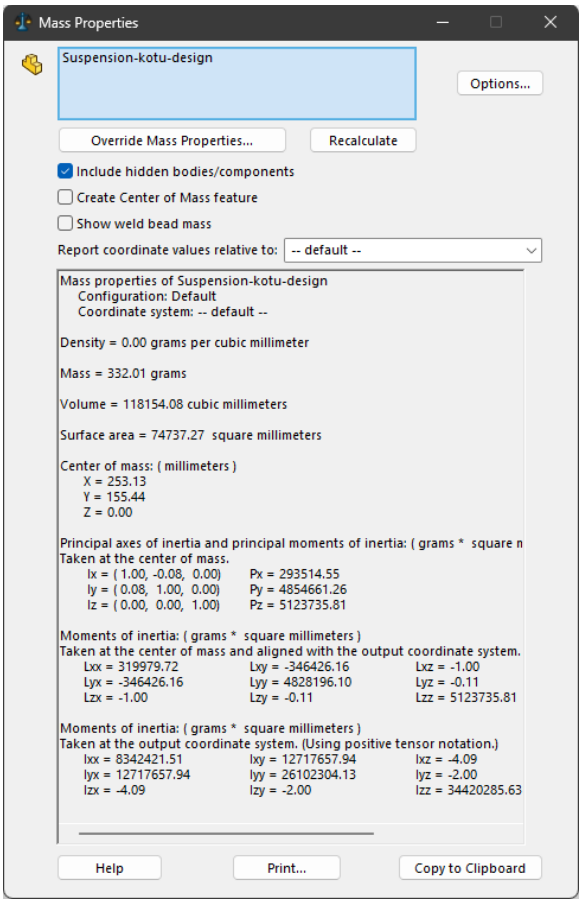

Figure 7: Mass Properties of Curved Design

It was clear that the mass of the curved rocker-bogie design was significantly lower than the square design therefore I selected the curved design for the shape of the suspension design.

Differential system

Next up I wanted to compare what might be the best differential system to link the right and left suspension system. I researched and found that there are two main systems namely.

- Mechanical differential linkage
- Cross-link differential bar

Mechanical differential linkage: A gearbox averages the rotation of the left and right rockers. When one arm rises the other side rotates down, making the body stay level.

Cross-link differential bar: long mechanical bar that physically links the left and right sides. As one side rotates, the bar transmits motion to the opposite side, forcing the chassis to follow the average position. [3][4]

Criterion	Cross-link bar	Mechanical differential (gears)
Manufacturability	High – few simple parts so fast to fabricate and assemble	Moderate – precision gears/housing; more machining and setup time
Reliability	High – tolerant to small misalignments; no gear backlash; visible wear points	Moderate – sensitive to alignment, backlash and lubrication. Enclosed faults can be harder to catch

Table 4: Comparison of differential system

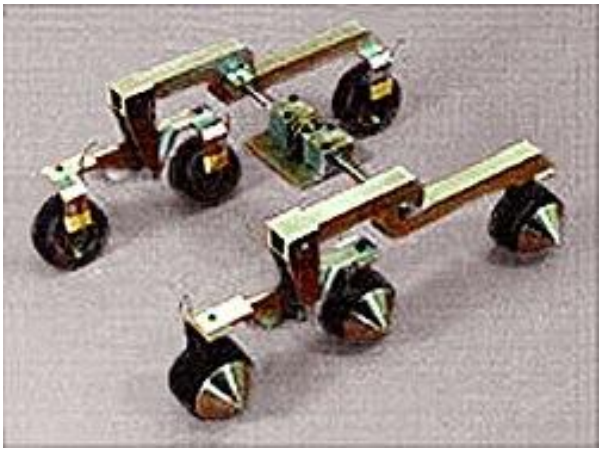

Figure 8: Mechanical differential (gears)

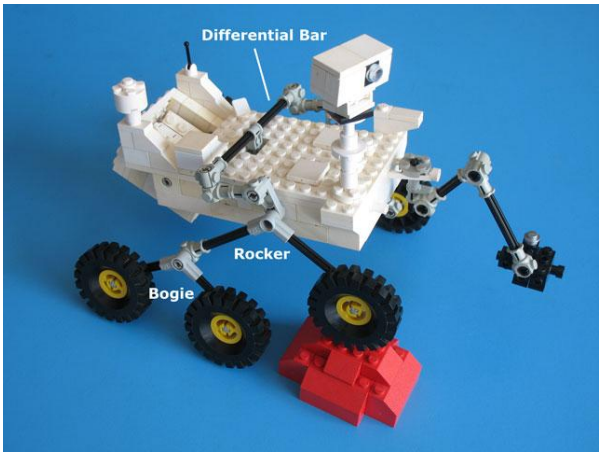

Figure 9: Cross-link bar

After the above research and with prior knowledge of Mars rovers such as perseverance using the crosslink system, I decided on using it as it came out to be the best option. Afterwards I began creating some rough design for the CAD design.

Suspension system with crosslink differential bar – CAD Modelling

Pre-Liminary Design:

To get the best idea of creating a suitable suspension system through SolidWorks I first created an outline of the rover using SolidWorks;

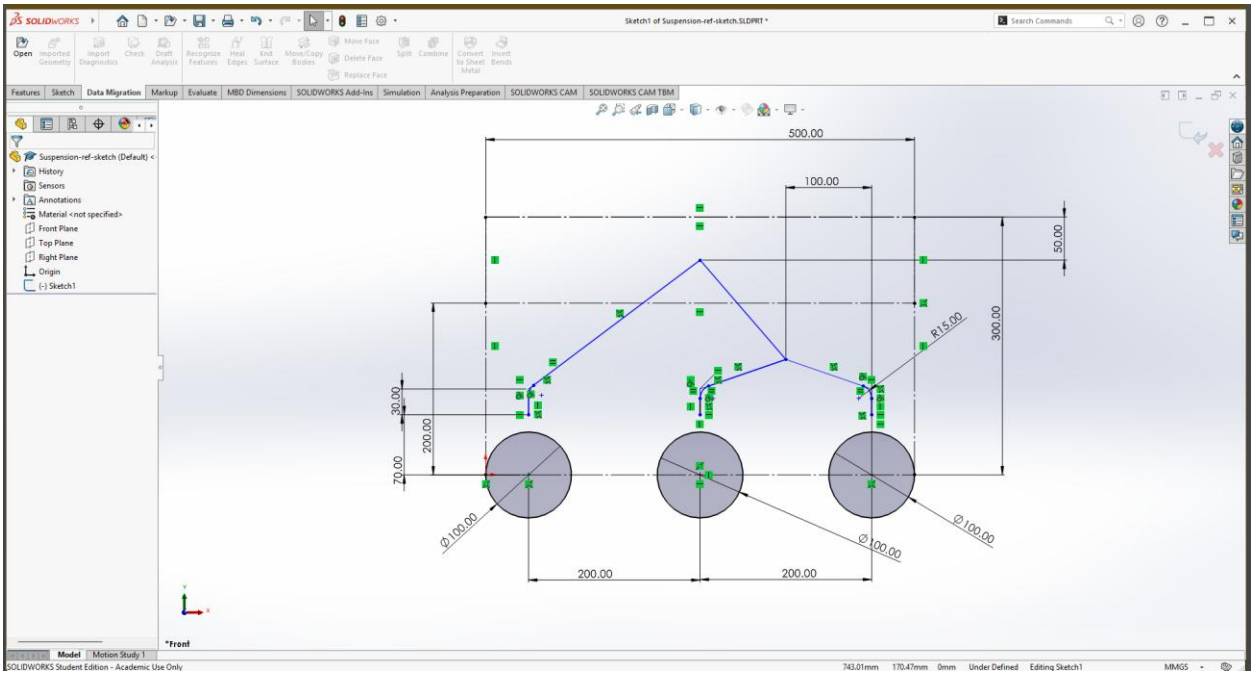

Figure 10: Screen shot of initial sketch of the Rover and suspension made using SolidWorks

Afterwards I realized that my sketch was incorrect as I've taken the dimensions from the highest point of the rover to the middle of the wheels as 300mm. This needed to be corrected so that the dimension from highest point of the rover to lowest point of the wheels is 300mm.

After fixing this I made several changes to improve accuracy of the sketch and features of the rover. These include,

- Changing the position of the front and the rear wheels. I kept a 10mm for the front and the back of the wheels, so it doesn't touch the transport container.

- Changing the end points of the suspension. Previously I didn't consider the motor having its shaft above the center of it. Therefore, after adding the drive strut height from the center of the wheels, I kept a 7mm offset.
- Added more definitions so that my sketch is fully defined.

The refined sketch is shown below,

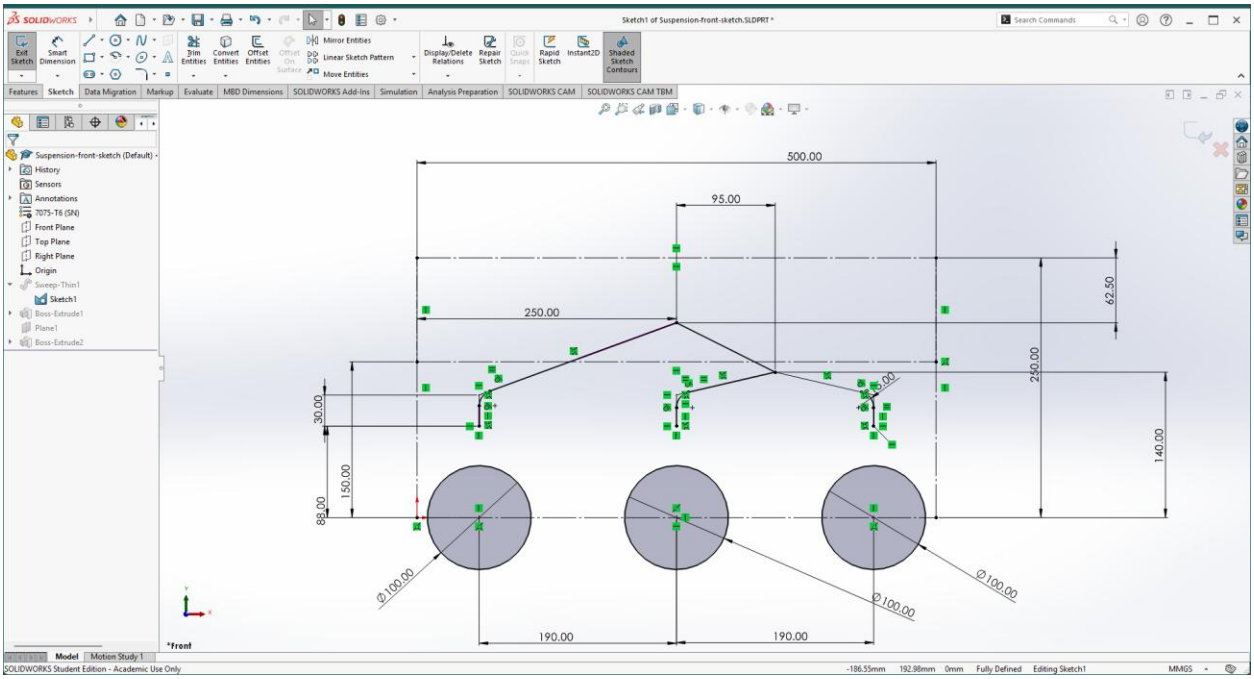

Figure 11: Screen shot of refined sketch of the Rover and suspension made using SolidWorks

For the preliminary design I only created the Assembly of the front and the rear rocker bogie suspension. The differential system was only added in the detailed design.

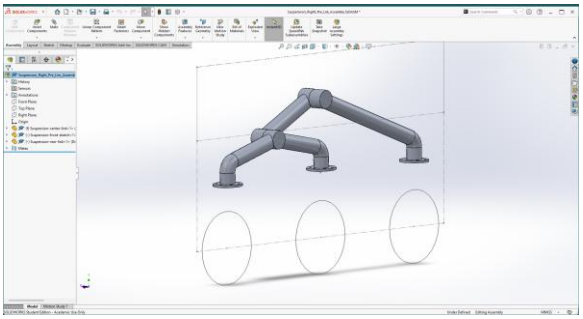

Figure 12: Pre-Liminary Assembly of the suspension system for the right side of the rover.

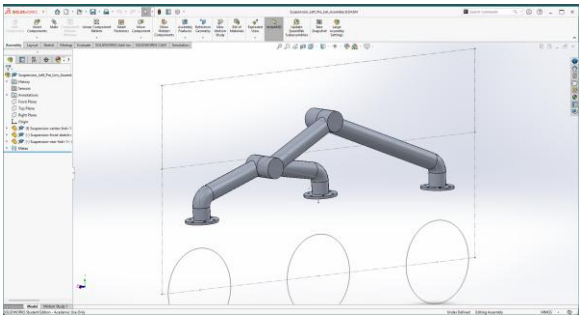

Figure 13: Pre-Liminary Assembly of the suspension system for the left side of the rover.

During this stage I also created simplified versions of other rover components (wheel, body, drive strut) in CAD. This was not part of my assigned task, but it helped me understand the

interfaces and clearances between the suspension and adjacent subsystems. Below are the components to create my own rover assembly.

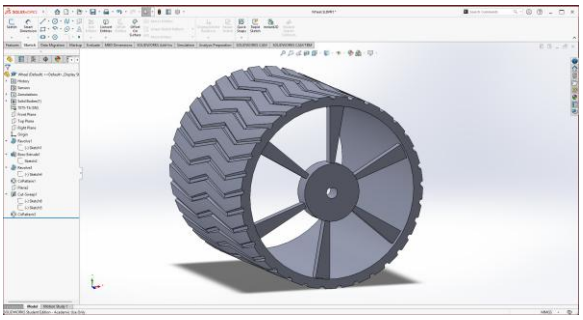

Figure 14: Pre-Liminary Wheel Design

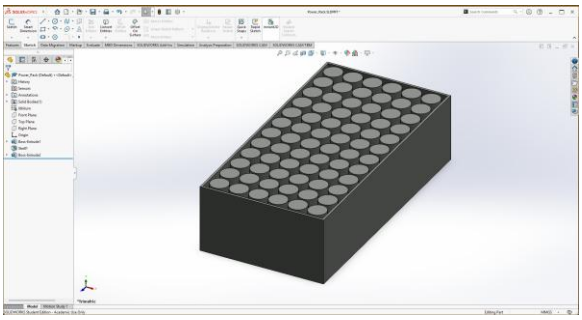

Figure 17: Pre-Liminary Power pack Design

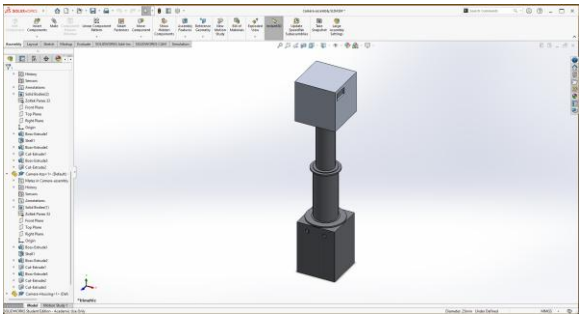

Figure 15: Pre-Liminary Camera Assembly

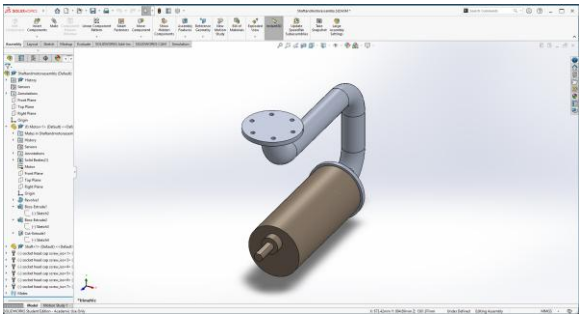

Figure 18: Pre-Liminary Motor and Strut Design

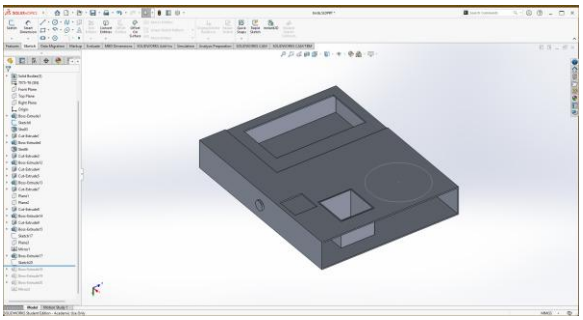

Figure 16: Pre-Liminary Body Design

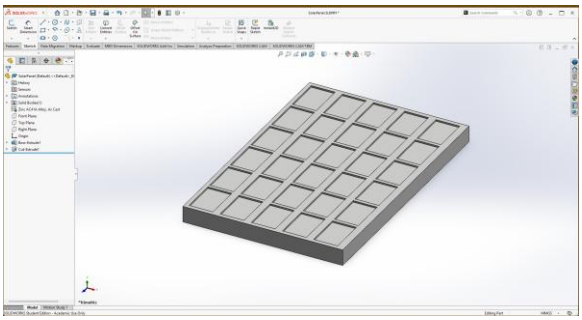

Figure 19: Pre-Liminary Solar Panel Design

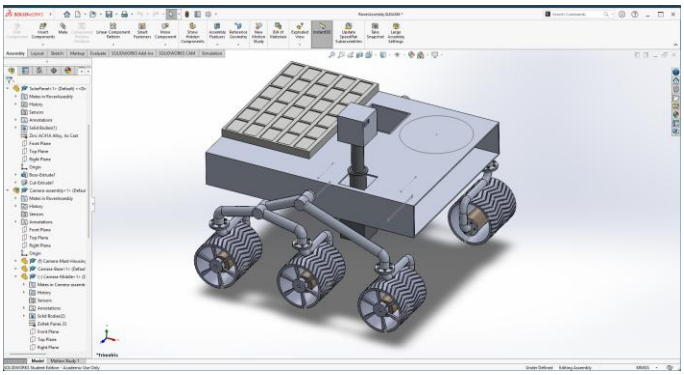

Figure 20: Pre-Liminary Rover Assembly

Detailed Design:

After sharing my pre-liminary design with my team, I started working on my detailed design. Beforehand I made a list of new details that I planned to add to as listed below,

- Adding the cross-link bar differential system.
- Creating the rocker and bogie as 2 parts instead of three parts.
- Fixing the Bogie in the same plane as the rocker to minimize the increase in width of the rover due to the suspension.
- Assigning suitable materials for the newly added differential links
- Adding fillets and other cosmetic features.

The detailed design of the suspension system turned out as below,

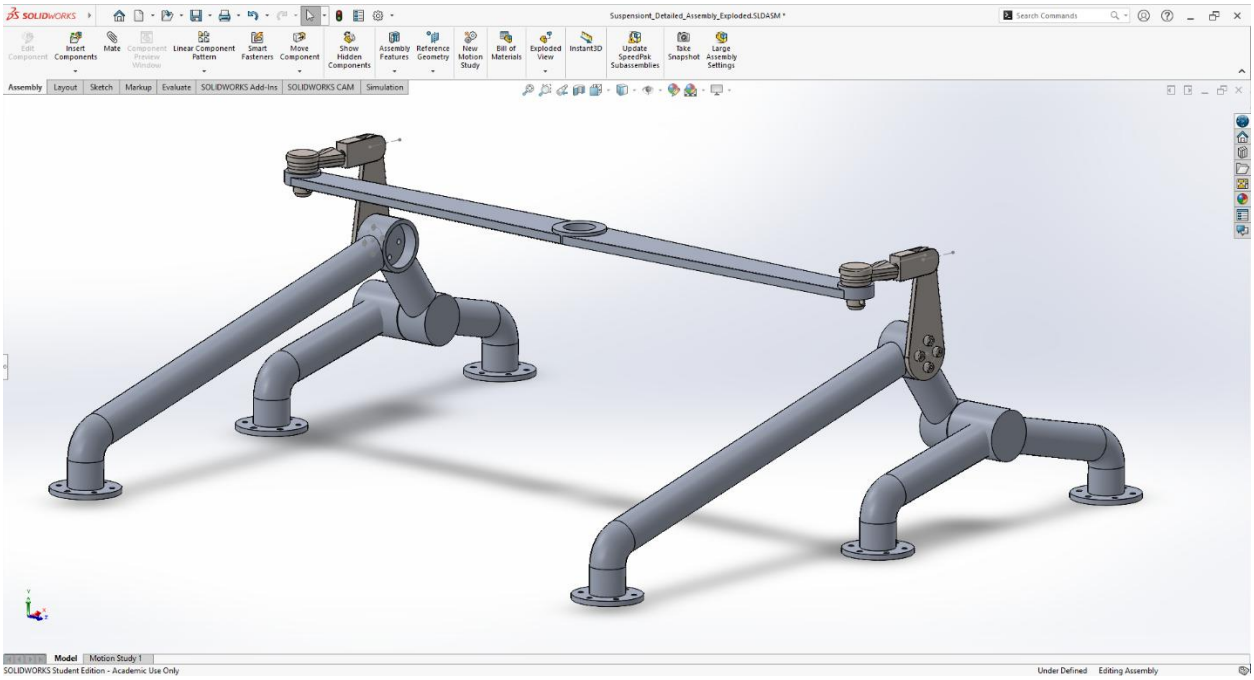

Figure 21: Assembly of the detailed design for the suspension system.

After creating the detailed design, I moved on to the rover subassembly.