

## Pedals & Brake Team

Original Product Design Course #034353/4  
Ziv Manger, Ishai Israel

Client: Nimrod Meller

Advisor: Giora Goral

### Abstract

The Pedals & Brake Team responsibility was to design and assemble a high performance pedals system including 2 pedals, clutch lever for ignition, routing the brake lines and selecting proper calipers. The team made analysis and performed calculations for braking forces acting on the vehicle and chose parts for the system accordingly. An optimization for the manufactured parts was made in order to achieve minimal weight for the required strength. Minimal weight was also achieved by mounting the pedal system in brackets welded to the chassis itself. In order to meet the volume requirement, the Master Cylinders were located under and in front of the pedals. The system includes two separate brake line circuits- one for the front wheels and another for the rear wheels. The forces, which are translated into pressure in the lines, are regulated by the balance bar for correlated brake of the four wheels.

### System's Modifications and Improvements

Category	2013	2014
Number of Pedals	3 same designed Pedals, Brake and Gas, including Clutch Pedal For Shifting Gears.	2 different exclusive designed Pedals, Brake And Gas, due to Automatic Transmission the Clutch functions as a starting Handle of the car, located in the Driver's Cell.
Brake Pedal Body	Weight: 447 gram	Weight: 294 gram That part is designed to be resistant in a force of 2000N according to Formula SAE 2014 Rules, and to provide Physical requirement of 1:5 Leverage Ratio.
Master Cylinders Location	Located in front of the Pedals the distance between the Pedals and the chassis front - 220 mm	Located under the pedals, the distance between the Pedals and the front section of the Chassis has been improved to be a mere 60 mm
Pedal's Foot	Smooth plain attached to The pedal body By bolts.	Bent sheet metal For foot slip resistance Attached to the pedal body by rivets.
Interfacing to the chassis	Manufactured base Board and fittings for the Systems' parts. Interfacing to the Chassis with bolts.	Designated brackets for the Pedals System parts, designed in corporation with Chassis Team. The Brackets are welded to the chassis.

### Product Description

#### How the Brake System works:

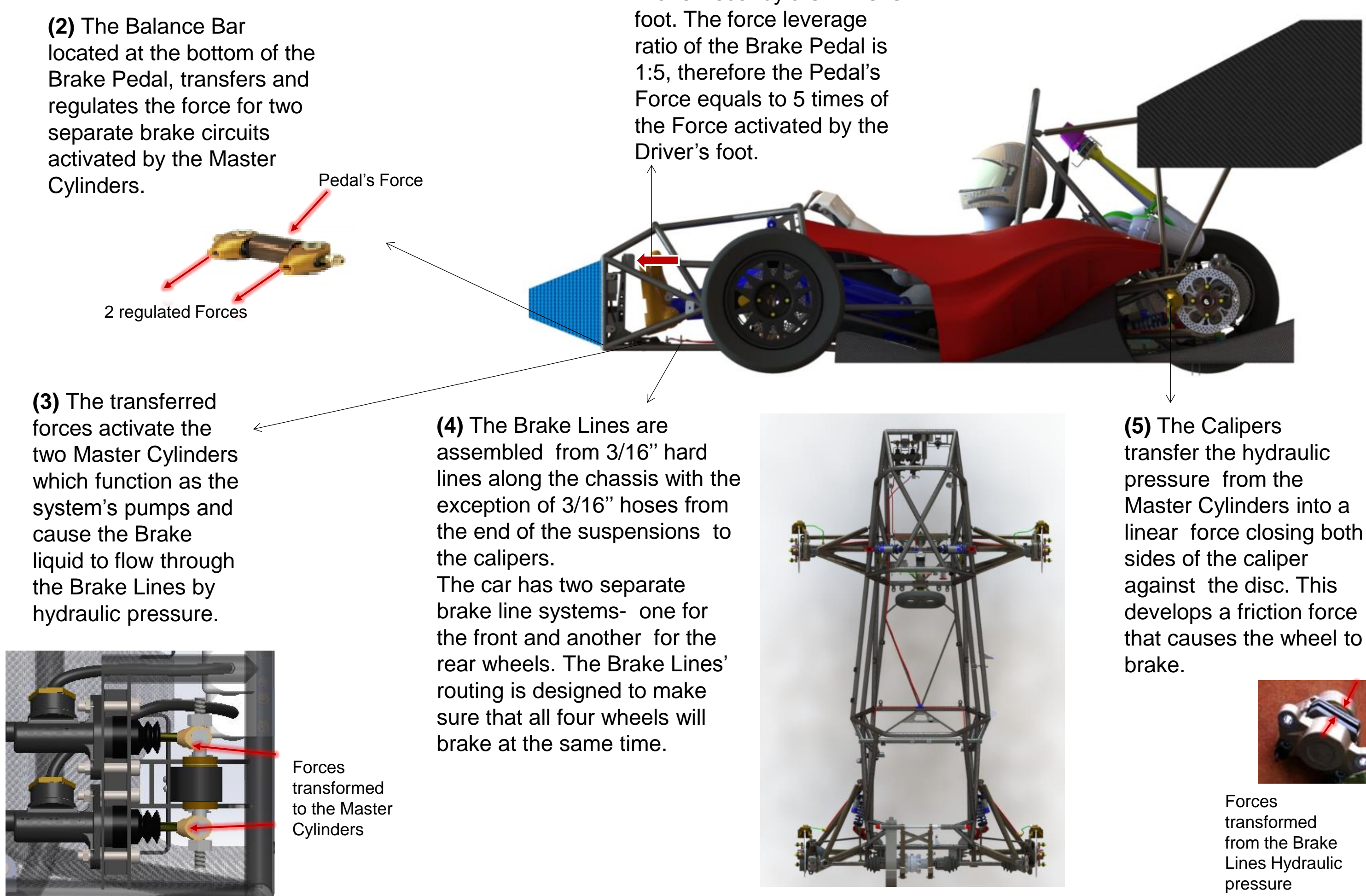
(2) The Balance Bar located at the bottom of the Brake Pedal, transfers and regulates the force for two separate brake circuits activated by the Master Cylinders.

(3) The transferred forces activate the two Master Cylinders which function as the system's pumps and cause the Brake liquid to flow through the Brake Lines by hydraulic pressure.

(4) The Brake Lines are assembled from 3/16" hard lines along the chassis with the exception of 3/16" hoses from the end of the suspensions to the calipers. The car has two separate brake line systems- one for the front and another for the rear wheels. The Brake Lines' routing is designed to make sure that all four wheels will brake at the same time.

(1) Force activated on the Brake Pedal by the Driver's foot. The force leverage ratio of the Brake Pedal is 1:5, therefore the Pedal's Force equals to 5 times of the Force activated by the Driver's foot.

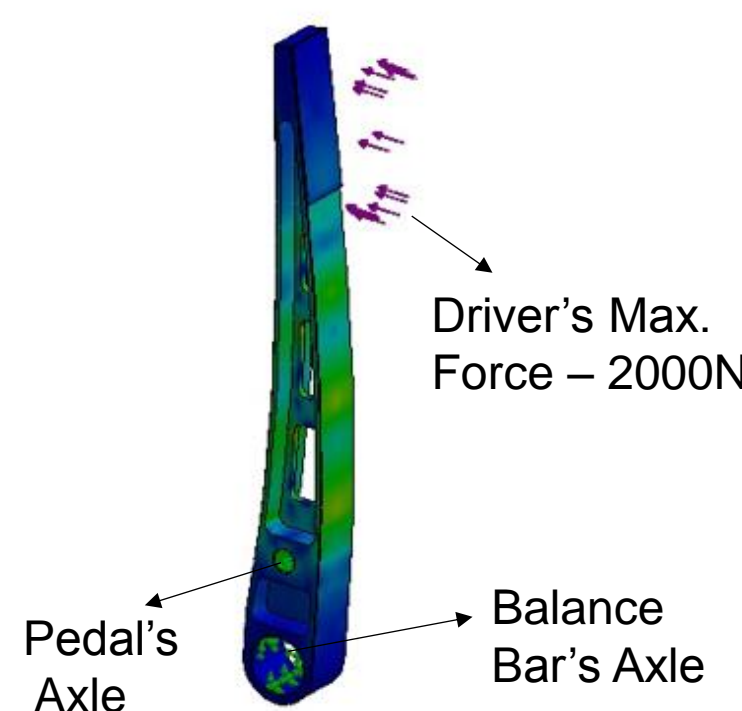
(5) The Calipers transfer the hydraulic pressure from the Master Cylinders into a linear force closing both sides of the caliper against the disc. This develops a friction force that causes the wheel to brake.



### Analysis and Calculations

During the design process, extensive calculations of the vehicle braking dynamics and the hydraulic systems were calculated. A parametric subroutine was developed where parameters of the pedals system were inputted and a comparison analysis was developed. Using this, an optimal, robust, and reliable Brake System was designed.

#### Brake Pedal Body:

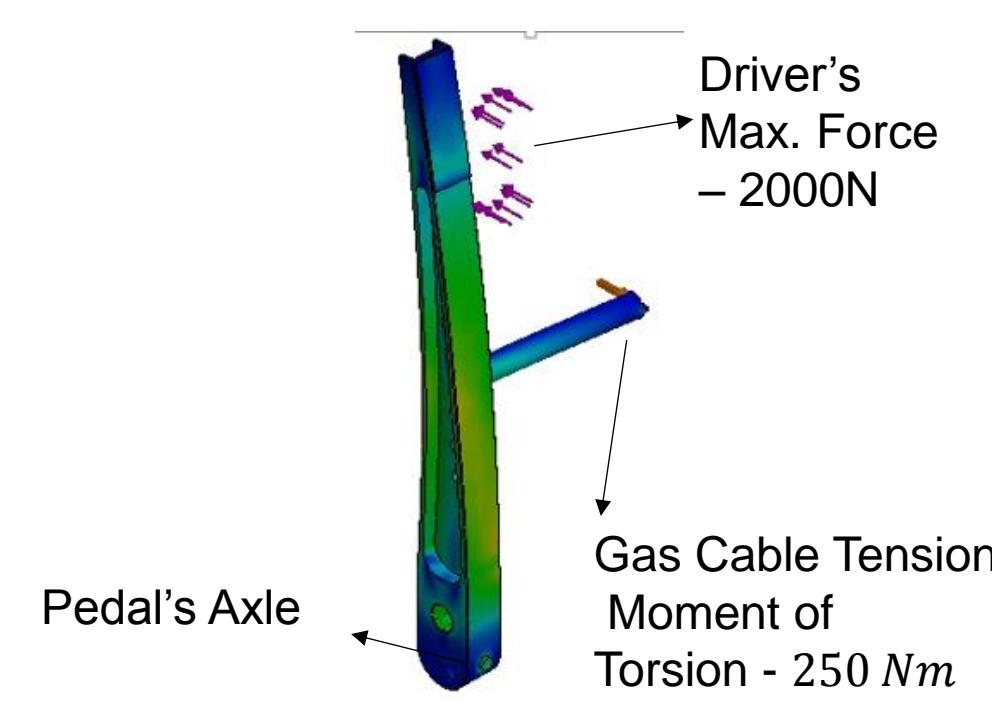


Brake pedal stroke is determined by the Master Cylinder's stroke, the caliper's strokes, and the leverage ratio according to the following equations:

$$L_{mc} = \frac{N_{cap} \times A_{cal} \times L_{cal}}{A_{mc}}$$

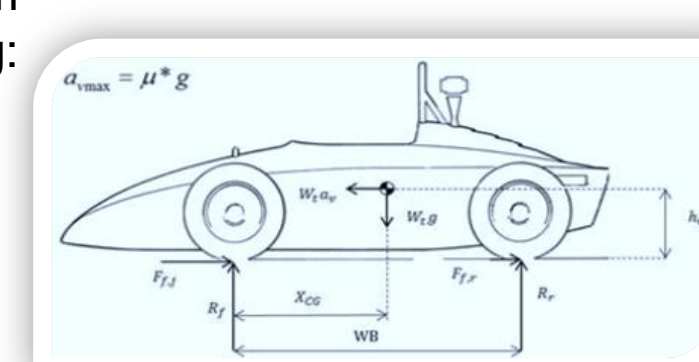
$$L_{pedal} = L_{mc} \times (L_2 \div L_1)$$

#### Gas Pedal Body:



Gas pedal stroke is determined by two adjustable bolts. The gas pulling shaft adds torsion which was taken in account.

Free Body Diagram of vehicle braking:



**Braking Ratio:** calculated from the free body diagram and from the torque caused the friction between the tire and the road by the following equations:

$$a_r = \mu g$$

$$R_f = \frac{W_{f,s}(WB - X_{cg}) + W_{a,d}H_{cc}}{WB}$$

$$R_f + R_r = W_f g$$

$$WT = \left( \frac{a_r}{g} \right) \times \left( \frac{H_{cc}}{WB} \right) \times W_r$$

$$W_{f,d} + W_{a,d} = W_f$$

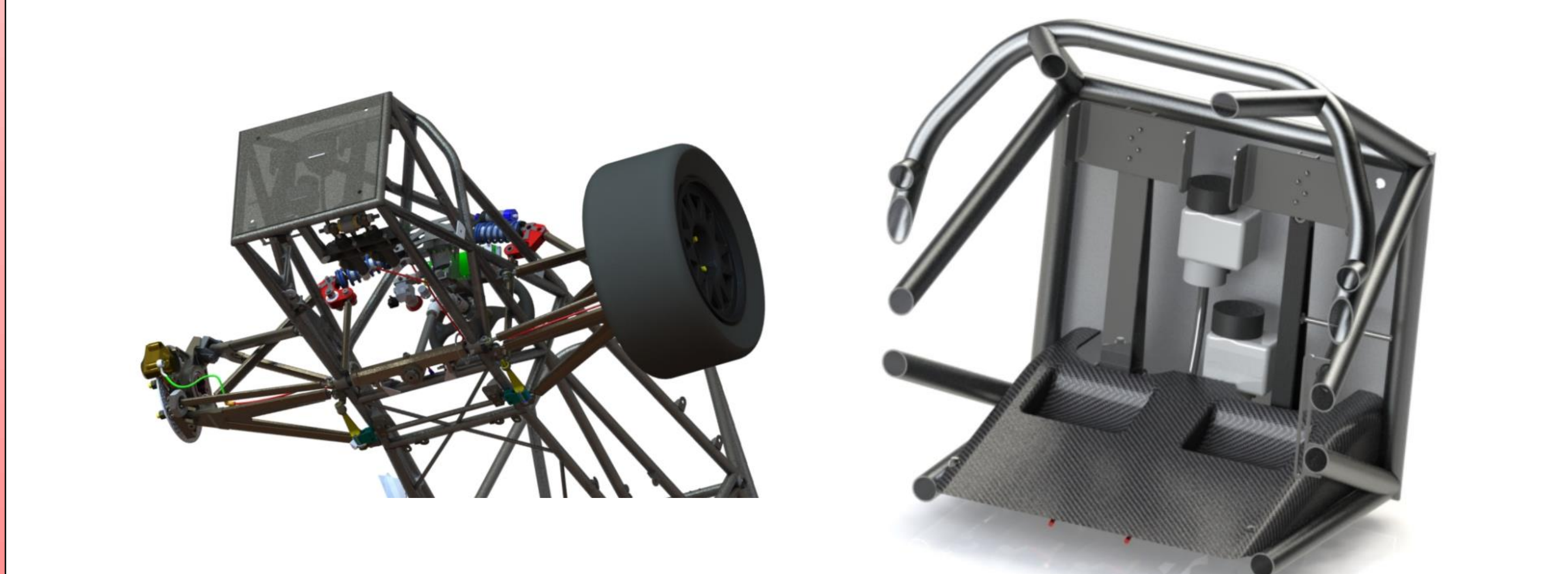
$$F_{a,f} = W_{f,d} \times \mu_r$$

$$T_{b,f} = F_{a,f} \times R_f$$

$$T_{b,r} = F_{a,r} \times R_r$$

$$BR = \frac{T_{b,f}}{T_{b,r}}$$

### Final Product



Brake Lines – Bottom view

Pedal System – Isometric view



Purchased Clutch Lever



Brake Pedal Body made of aluminum 7075, manufactured in milling and black anodized



Support Plate for driver's Heels - made of Carbon Fibers



Brake Pedal Body and Master Cylinders assembled in the chassis front section



Pedals System's Brackets, designed in corporation with Chassis Team, made of steel ST-52, manufactured in laser cut



Purchased Balance Bar Tilton 72-260 and Master Cylinders Tilton 76-700, Tilton 76-750



Pedal Foot made of aluminum 5052, manufactured in laser cut and bent

### Acknowledgements

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