Differential Mount CAD Design

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Force Simulation on the mount

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Attempted - Mechanical Subsystem

- Introduction :

The differential is a gearbox placed between the drive wheels. Vehicles that are four-wheel drive will have both a front and a rear differential. The function of a differential is to transmit power from the engine to the axle that moves the wheels and allow the wheels to move at different speeds from each other.

TASK: Designing a mount for a simplified differential model (Mounting a Cylinder on two rods using a mount and brackets (for attaching the mount to the rods))

- Design Specification:
  - Two parallel rods with 15 cm vertical distance
  - Cylinder dimensions: 11 cm diameter, 20 cm length
  - Separation of axis of cylinder and centerline of the axis of the two rods is 12 cm
  - Weight of the cylinder to be 10kg
  - The horizontal plane that passes through the center of the axis of the two rods also contains the axis of the cylinder.

- **CAD Design process and its components :**
- Components:

Bodies	No. of Bodies for corresponding components
1. Cylinder	x1
2. Rods	x2
3. Mount	x2
4. Brackets	x8

- Designing of Components:

1. Cylinder:

The cylinder , which is to be mounted by the rods , is drawn by extruding the sketch of an circle in the perpendicular plane.

Diameter: 110 mm Length: 200 mm

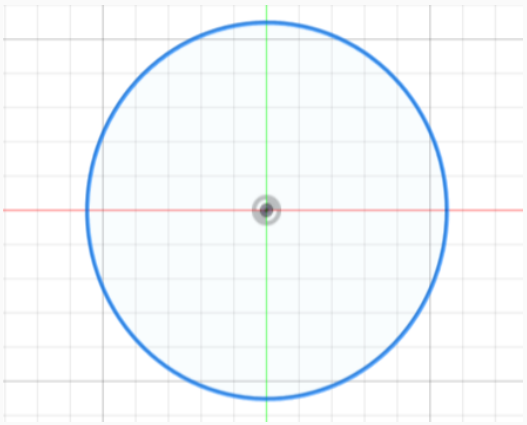


Fig. Sketch

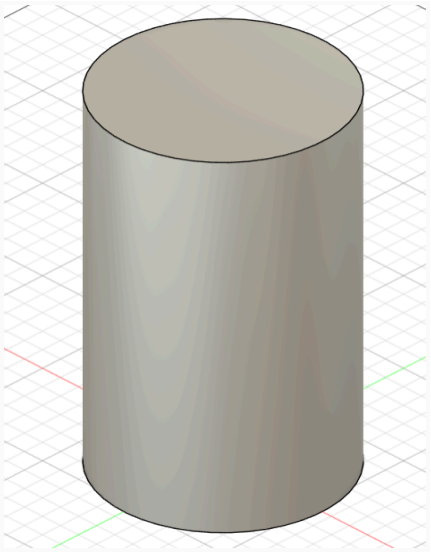


Fig. Cylinder (after extrusion of sketch)

2.Rods:

The rods , which are used for mounting , are drawn in a similar way to the cylinder (by extruding the simple sketch)

Diameter: 25.4 mm Length: Not specified but i have take 20mm

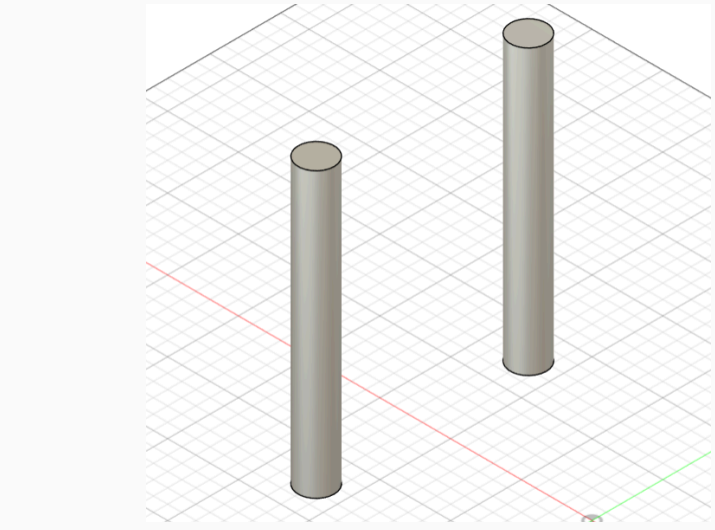
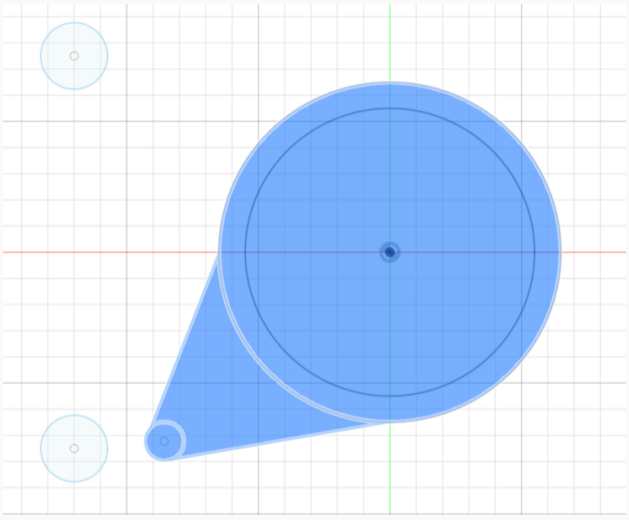


Fig. Rods

3.Mounts:

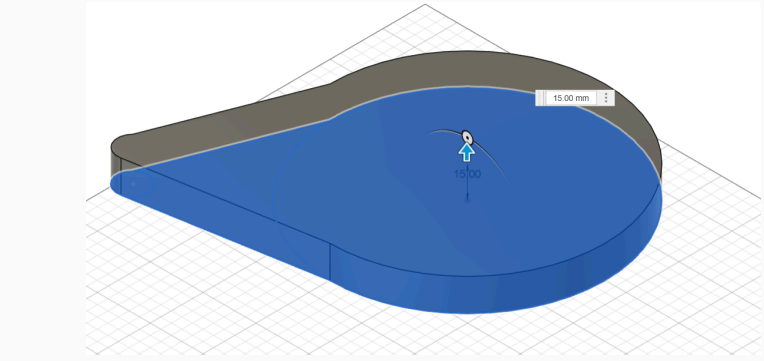
The Mount in our case is the link between the rods and the cylinder (it is linked to the bracket which in turn is linked to rods).



Explanation of the sketch :

The sketch is basically divided into 3 parts : smaller circle , larger circle (with diameter >110 mm), region between the region between the two lines (tangent of the smaller circle and passing through the two point of circles where it cuts the axis)

This is the sketch of only the half part of my mount . Now to make it complete i have extruded it 15 mm (finalized it after iterations(simulating the forces)) and then mirrored it with respect to the axis plane(red) to get the basic shape of the mount. Now hollowing it so that the cylinder could fit in & making holes so that the brackets could be fixed with the mount .



Final Structure :

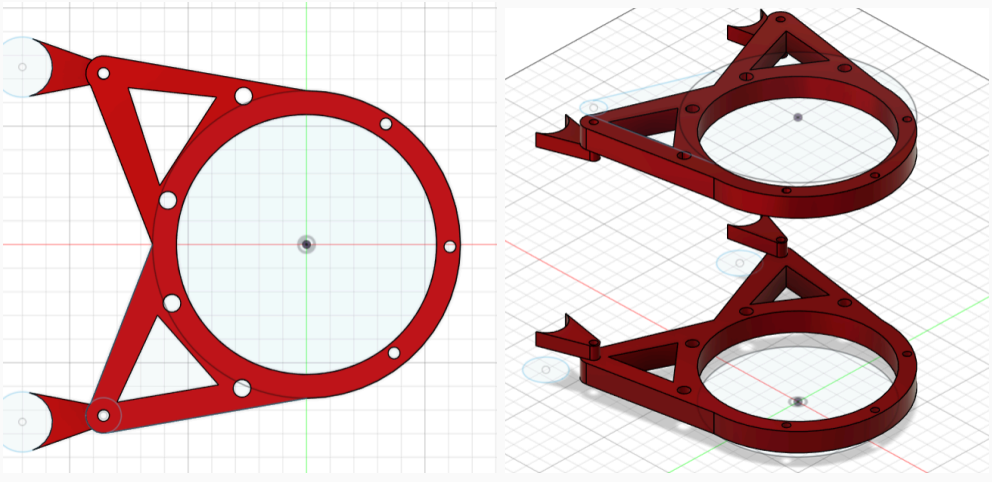


Fig. Mounts in different views(along with 2 brackets on each mount)

REASON FOR SUCH A STRUCTURE DESIGNING:

- Improved Integration with Chassis and drivetrain:

  This mount design enhances the integration with the vehicle's chassis and drivetrain components. By attaching the differential directly to the engine instead of the frame, it creates a more compact and efficient drivetrain layout. This integration can result in improved packaging and possibly better weight distribution.

- Serviceability :

  The design typically includes features that enhance maintenance and serviceability:

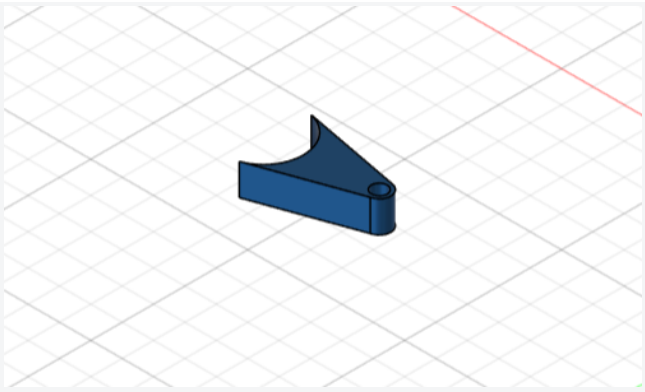
  Components that can be easily removed to provide access to the axle and other drivetrain parts.

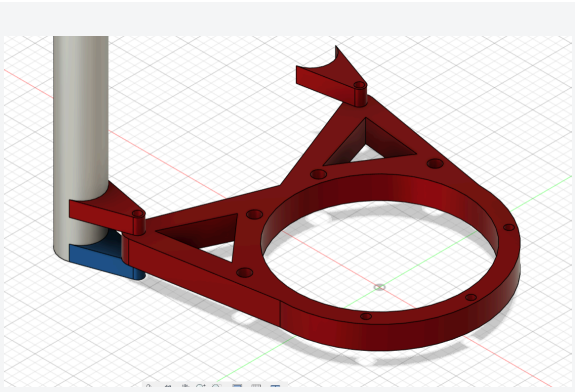
- Weight Reduction:

  A key reason for this mount design is to decrease the vehicle's overall weight. By removing parts such as the differential box and refining the mount structure, substantial weight reductions can be realized while still maintaining strength. This is especially crucial in racing and high-performance scenarios where every gram counts.

4.Brackets

Brackets are used as a link between rods and the mounts (connection between rod and mount)





Procedure of making brackets (from sketch):

- Sketch:

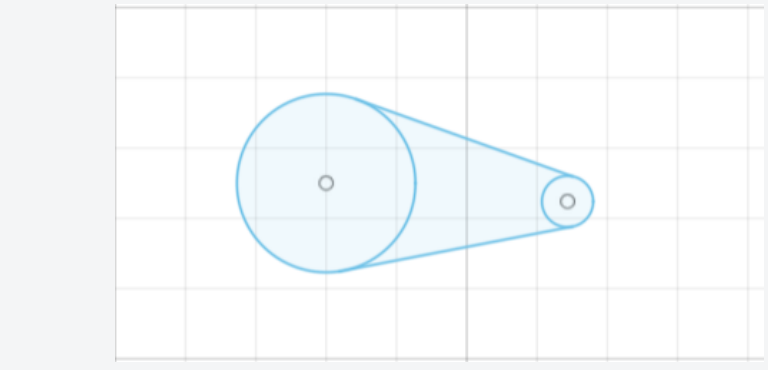


Fig.Sketch

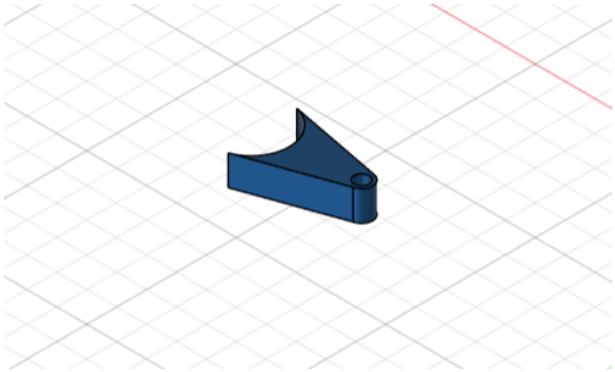
The sketch consists of of a smaller circle , larger circle and 2 common tangents of the circle . the larger circle has radius equal to the rod's radius and the smaller circle has radius greater then the hole cut out of mount to attach the bracket(finalized it after doing the force simulations)

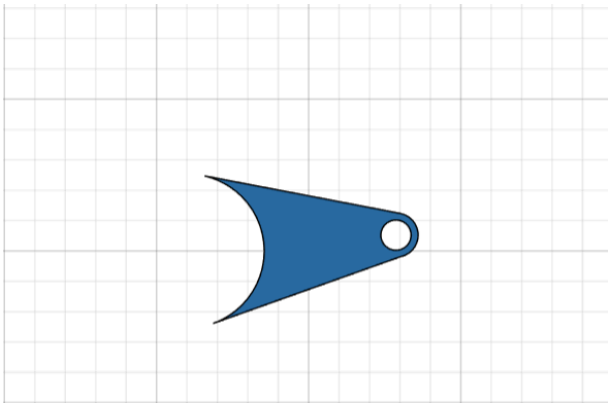
Extruding:

Now extruding it by 10 cm (finalized it after force simulations) cutting two holes:

1) Equal to the radius of rod in the larger circle
2) Equal to the radius of hole on mount to attach the bracket in the smaller circle

Final Brackets:





REASON OF CHOOSING THIS DESIGN:

- Offers dual-sided support, making it perfect for managing both horizontal and vertical forces.

- Encases the differential mount on both sides, stopping bending and twisting when torque is applied.

- Promotes improved load distribution, particularly when dealing with dynamic forces.

- Facilitates easier alignment and a secure connection to the chassis.

COMPLETE ASSEMBLY
(MOUNT+BRACKETS+CYLINDERS+RODS)

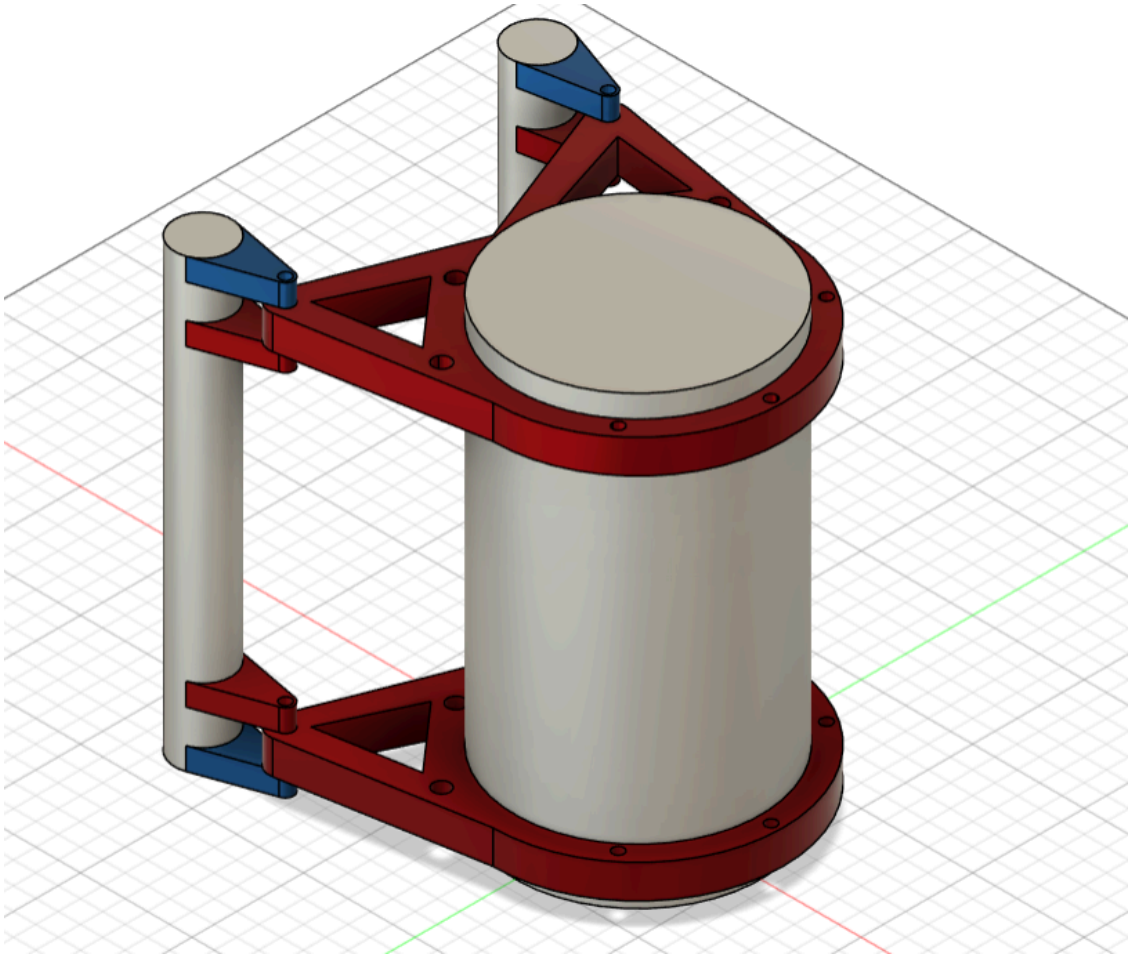


Fig. Complete Assembly

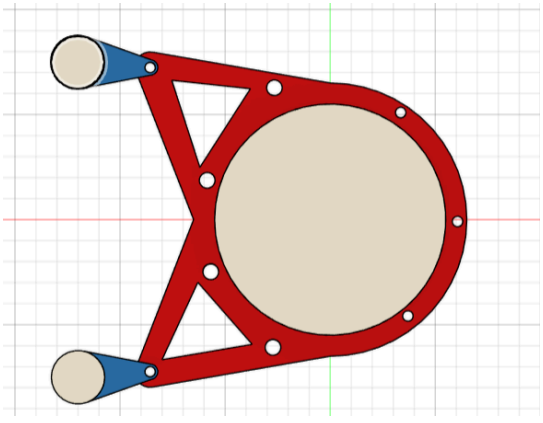


Fig.Top view

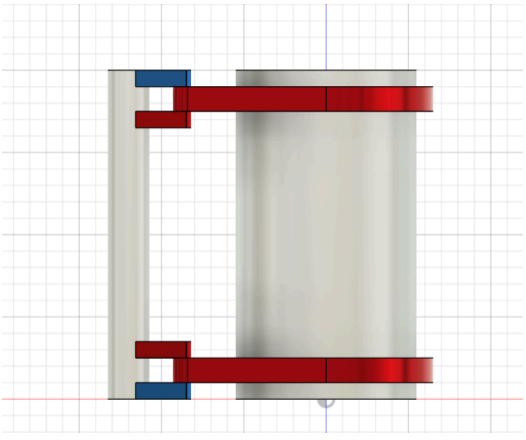


Fig.Side view

Physical Material Selection :

I have used the following physical material as per each component:

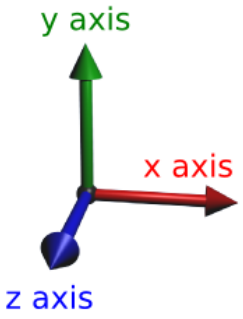
	Component	Physical Material
1)	Cylinder	Aluminum 6061-T6 Cold formed
2)	Rods	Aluminum 6061-T6 Cold formed
3)	Mounts	Aluminum 6061-T6 Cold formed
4)	Brackets	Aluminum 6061-T6 Cold formed

I have used **Aluminum 6061-T6 Cold formed** due to the following reasons:

1. High Strength-to-Weight Ratio
2. Corrosion Resistance
3. Excellent Machinability & Weldability
4. Cold Forming Improves Structural Integrity
5. Cost-Effective Alternative to Titanium & Stainless Steel
6. Suitable for High-Factor-of-Safety Applications

Material	Pros	Cons	Common Uses
Aluminum (6061-T6, 7075-T6)	Lightweight, high strength-to-weight ratio, corrosion-resistant	More expensive than steel, less rigid	Aerospace, automotive brackets, lightweight structures

FORCE CALCULATIONS:



Given , downforce of acceleration 20g m/s^2 & longitudinal force of acceleration 40g plus the gravity on the cylinder (mass=10 kg)

According to my CAD design reference axes , longitudinal force is along -x direction and downforce & gravity is along -y direction

F_x = -40x9.81x10= -3924 N
F_y = -20x9.81x10= -1962 N
gravity(along -y) = 10x9.81= 98.1 N

The longitudinal and downforce on the inner circular faces of the mounts and gravity on the cylinder

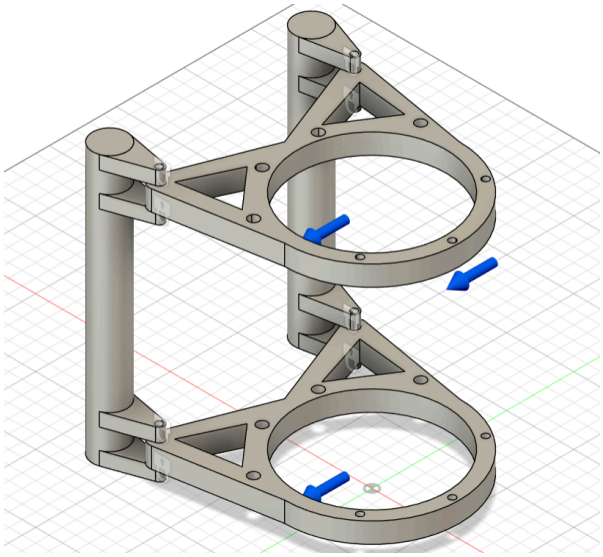


Fig.Downforce

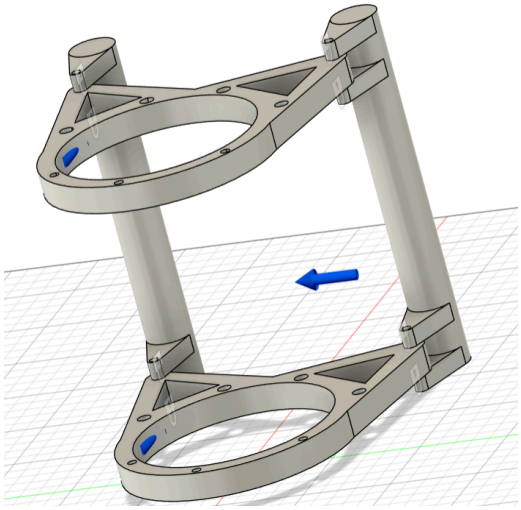


Fig.Longitudenal

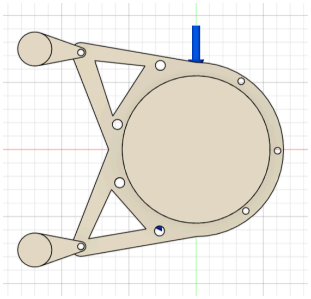


Fig.Gravity

FORCE SIMULATION:

In force simulation , we study the behaviour of our body when different forces are applied on it . Like whether the body will sustain the forces or will break . also the distribution of stress along every part of the body .

- Factor of Safety (FoS)

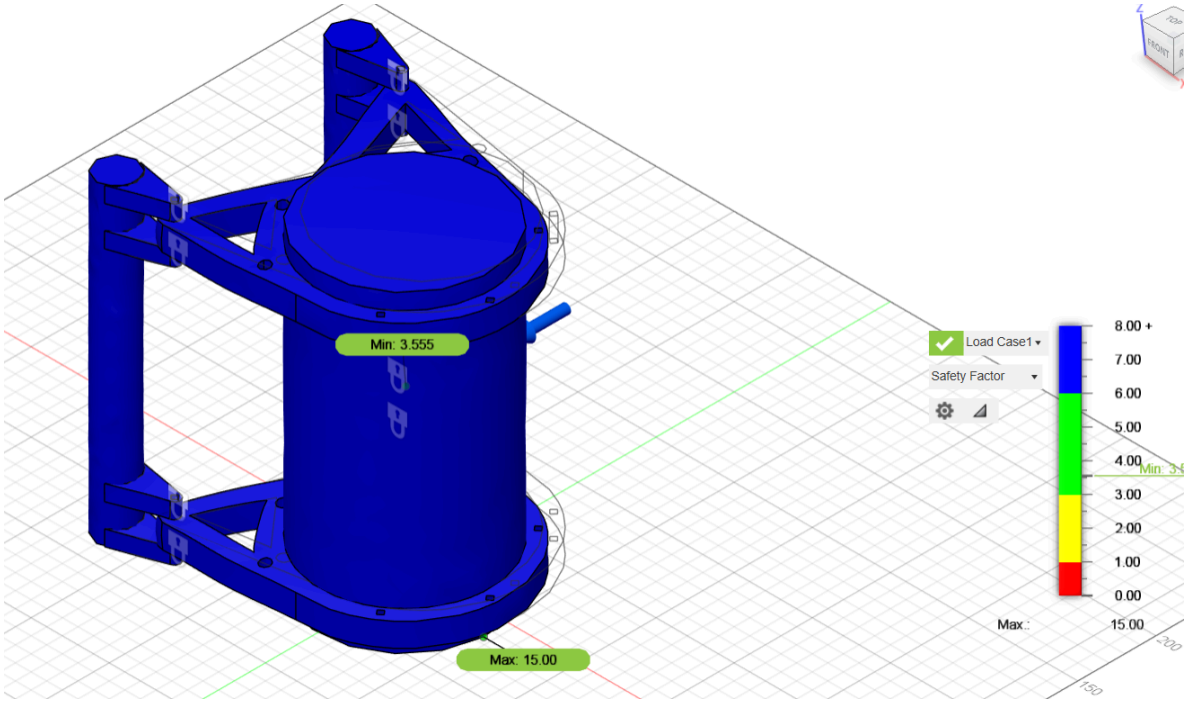
  The calculated FoS indicates safe/over-designed structure (whether over engineered or could not sustain the forces).

  If FoS was too high, modifications such as reducing thickness or adding cutouts were considered

<u>Simulation of Downforce :</u>

The following is my simulation of the factor of safety and stress distribution on the application of downforce and gravity (no longitudinal force)

- Factor of safety:



Result: Factor of Safety = 3.55

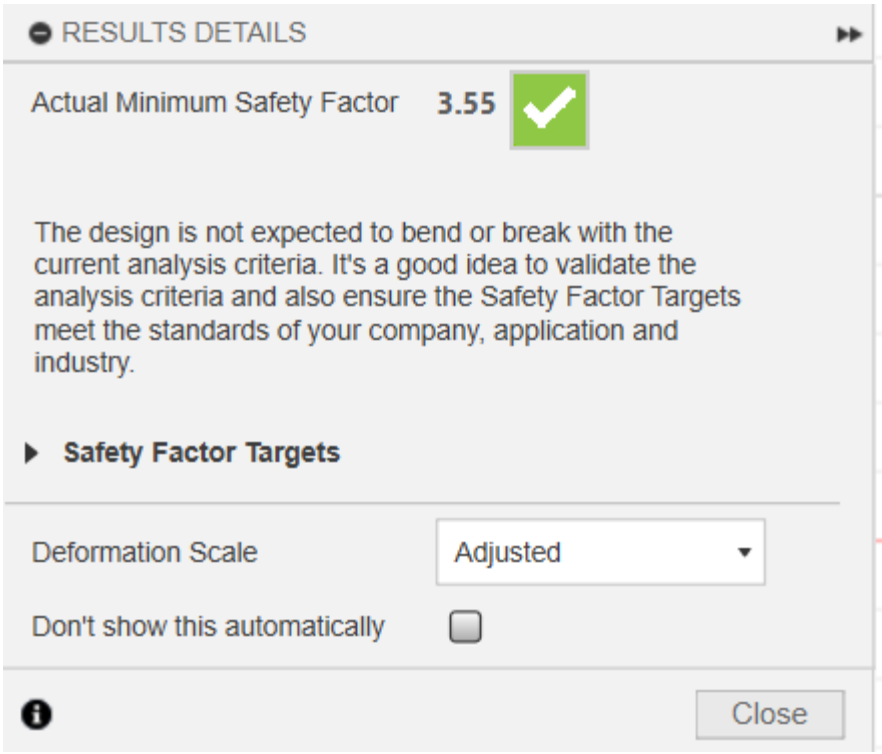


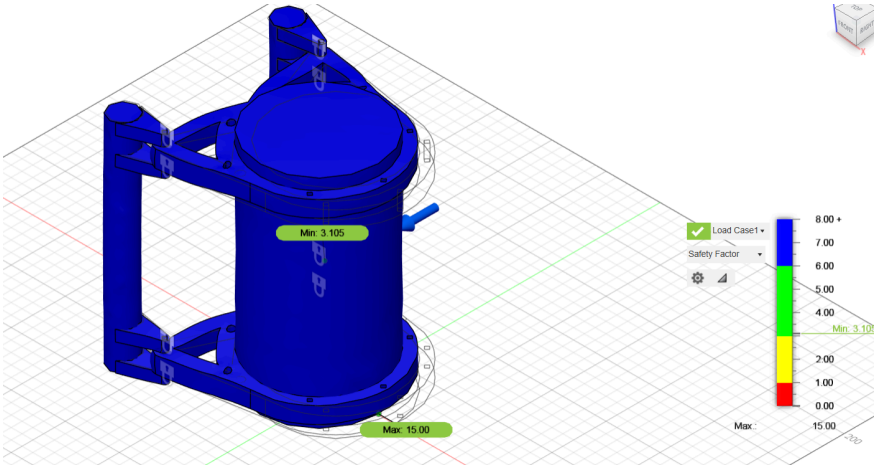
Fig. Result

We know that , we require a factor of safety between 3 to 5 for proper functioning of the mount in our case

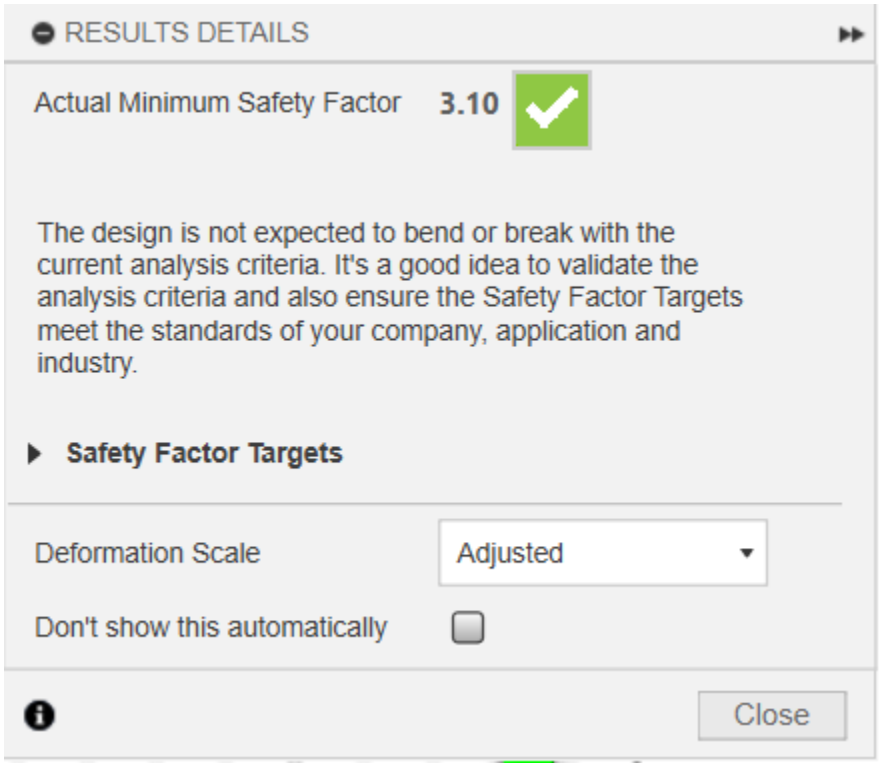
According to my result , it is satisfied and thus can sustain the above given downforce

Simulation of Longitudnal force :

The following is my simulation of the factor of safety and stress distribution on the application of longitudinal force and gravity (no downforce)



RESULT: FACTOR OF SAFETY=3.105



We know that , we require a factor of safety between 3 to 5 for proper functioning of the mount in our case

According to my result , it is satisfied and thus can sustain the above given longitudinal force

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