STEERING

3.1 KNUCKLE

The knuckle attaches to the suspension and steering components. Since it is a connecting medium it is necessary for the knuckle to be firm. It should be flexible enough to optimize in terms of weight and durability. Hence, the usual stress and deformation tests are conducted to ensure the knuckle is of good material and the factory of safety is then calculated as well. The material selected is Aluminum 6063 T6.

3.1.1 FRONT KNUCKLE

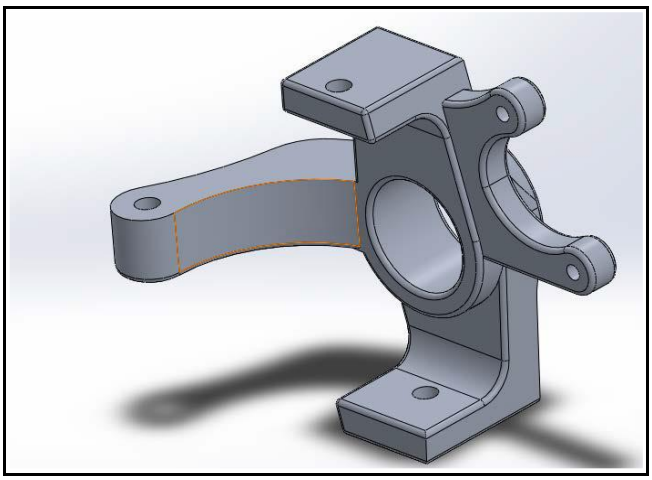


Figure 1 : Front Knuckle CAD Model

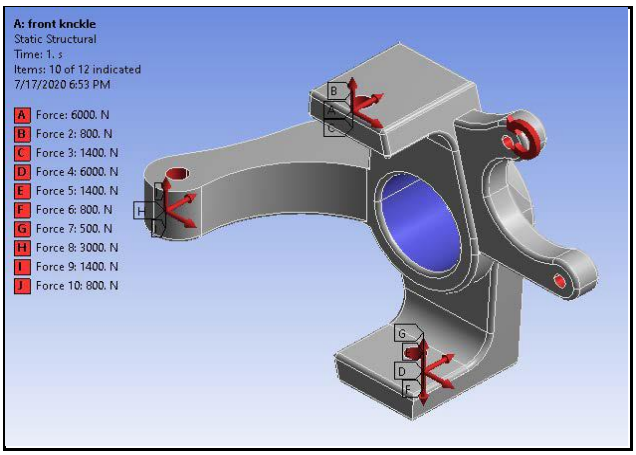


Figure 2 Front Knuckle with forces and constraints

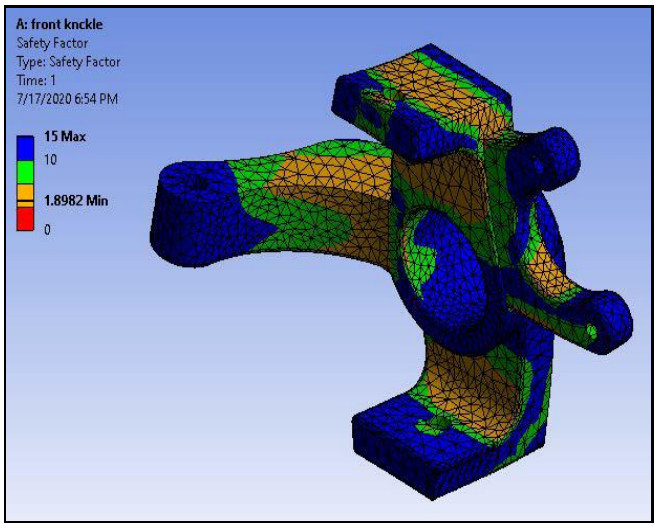


Figure 3: Factor of Safety

Unacceptable	Acceptable	Excellent
0-1.9	1.9-10	10-15

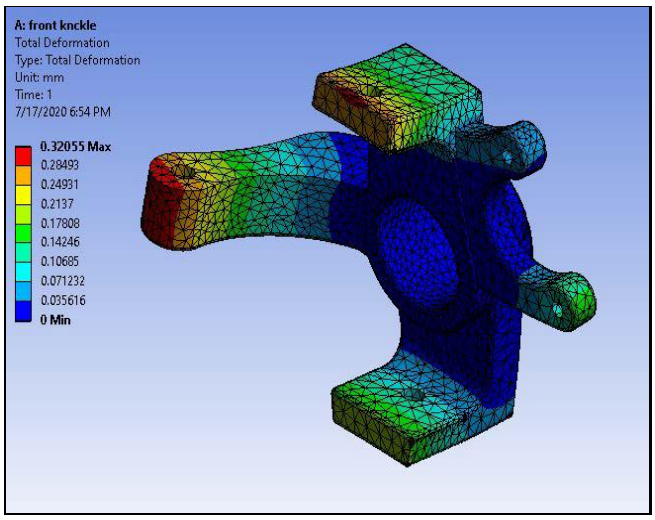


Figure 4:Maximum Deformation

Excellent	Very Good	Acceptable	Bad	Unacceptable
0 - 0.07	0.07 - 0.14	0.14 - 0.17	0.17- 0.24	0.24 - 0.32

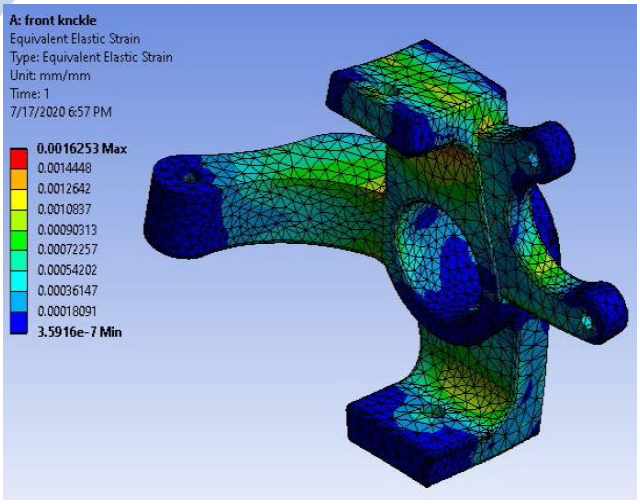


Figure 5: Equivalent Elastic Strain

Excellent	Very Good	Acceptable	Bad	Unacceptable
3.6e-7 - 0.2	0.2 - 0.5	0.5 - 0.8	0.8- 1.0	1.0 - 1.6

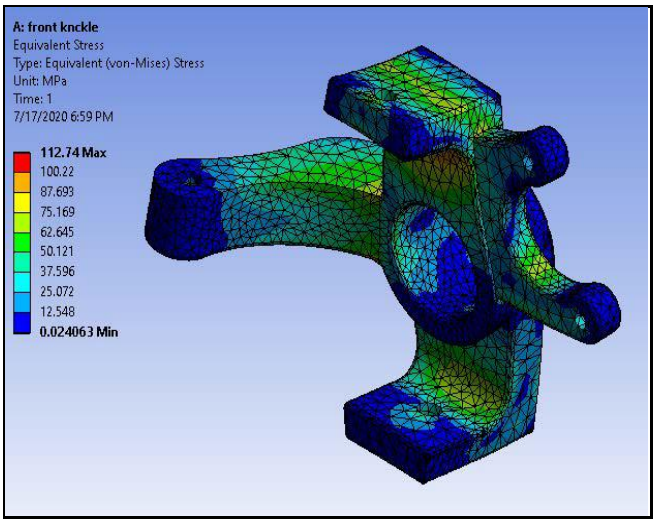


Figure 6: Von-Mises Stress

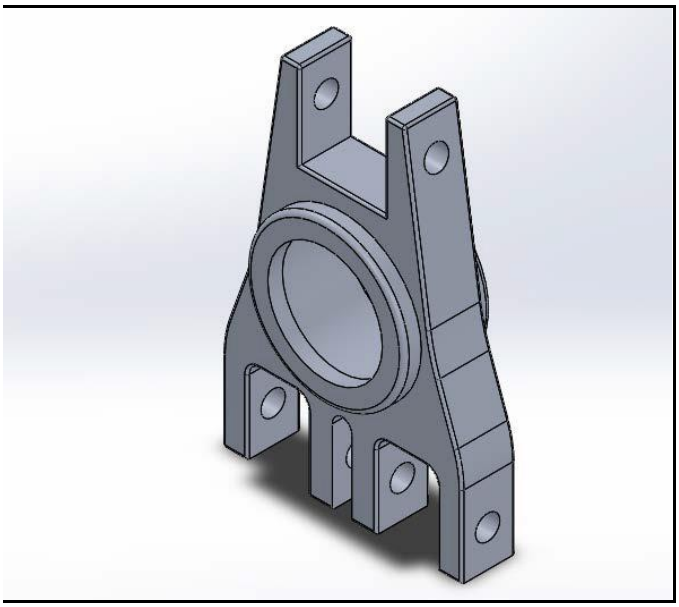
Excellent	Very Good	Acceptable	Bad	Unacceptable
0.02 - 25.07	25.07 - 50.12	50.12 - 75.17	75.17 - 100.22	100.22 - 112.74

FRONT KNCKLE ANALYSIS CONCLUSION

Sr. No.	Parameters	Values Obtained
1	Maximum Deformation	0.32 mm
2	Von-misses stresses	112.74 MPa
3	Equivalent Elastic Strain	0.0016 mm/mm
4	Factor of safety	1.9

- So, we did various analysis on knuckle like
  1. Max equivalent stress
  2. Total Deformation
  3. Von Misses stress analysis
  4. Von Misses strain analysis
- Here, while testing we applied various forces like
  1. Drop force = 8000 N
  2. Lateral force = 1404.29 N
  3. Longitudinal force = 779.857 N
  4. Bump force = 3312 N
  5. Vehicle's weight = 460 N
- After performing the analysis mentioned above we found that
  1. Factor of safety = 1.9
  2. Maximum deformation = 0.32mm
  3. Von Misses stress = 112.74 MPA
  4. Equivalent Elastic Strain = 0.0016
- And after all the analysis the values we got were sometimes acceptable and sometimes excellent

3.1.2 REAR KNUCKLE



\ *Figure 7: Rear Knuckle CAD Model*

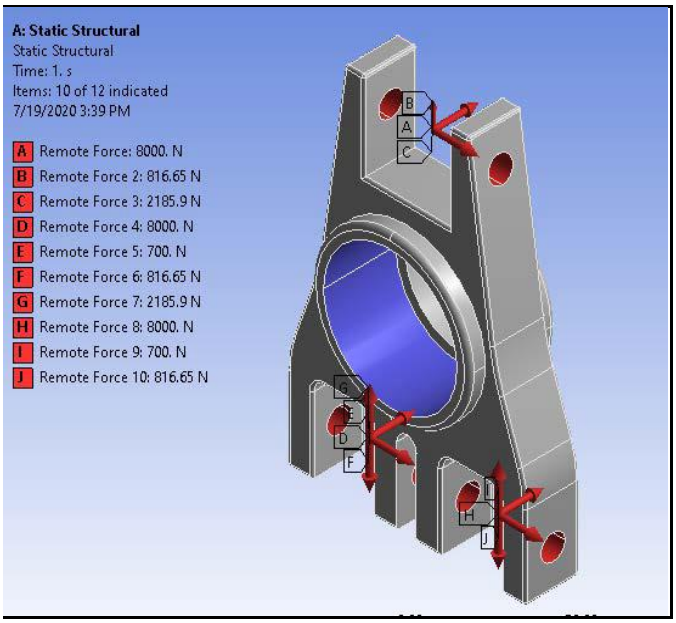


Figure 8: Rear Knuckle with forces and constraints

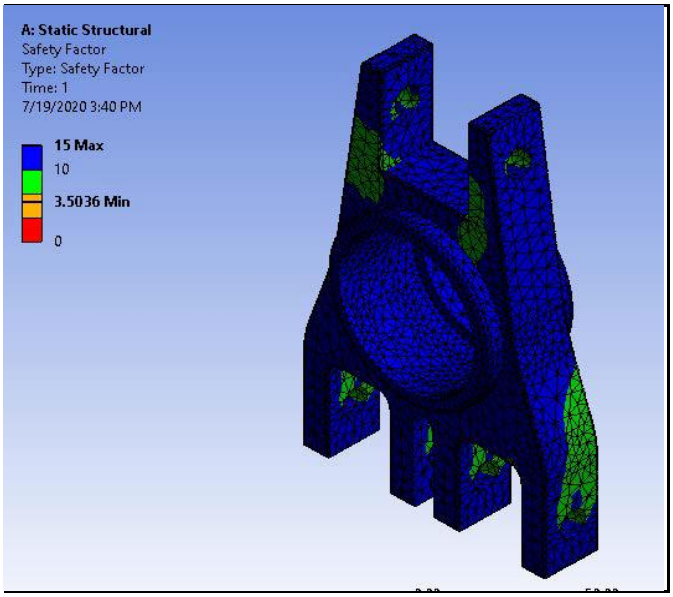


Figure 9: Factor of Safety

Unacceptable	Acceptable	Excellent
0-3.5	3.5-10	10-15

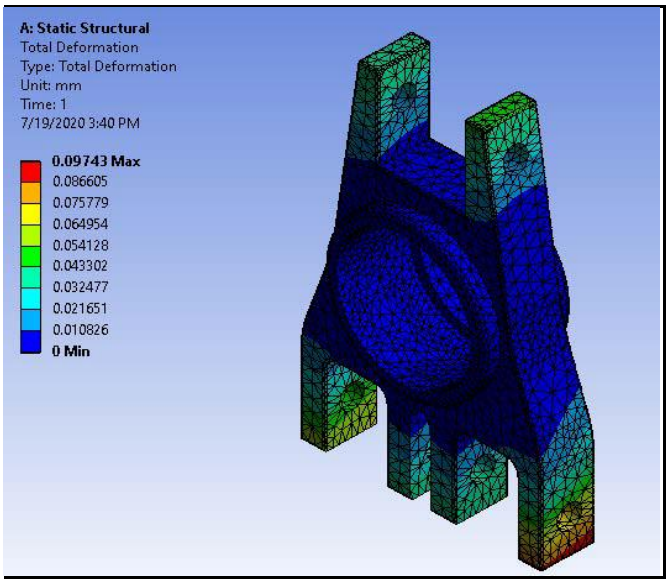


Figure 10: Maximum Deformation

Excellent	Very Good	Acceptable	Bad	Unacceptable
0 - 0.02	0.02 - 0.04	0.04 - 0.06	0.06 - 0.08	0.08 - 0.10

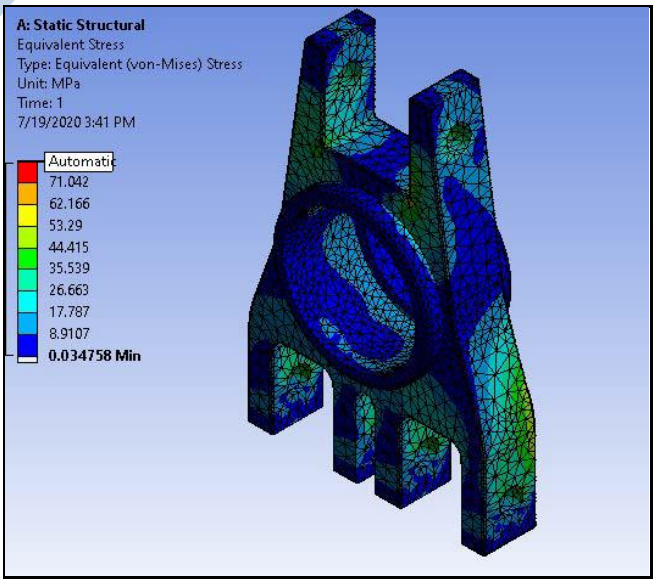


Figure 11: Von-Mises Stress

Excellent	Very Good	Acceptable	Bad	Unacceptable
6.12e-7 - 3.08	0.3 - 0.6	0.6 - 0.7	0.7 - 0.9	0.9 - 1.3

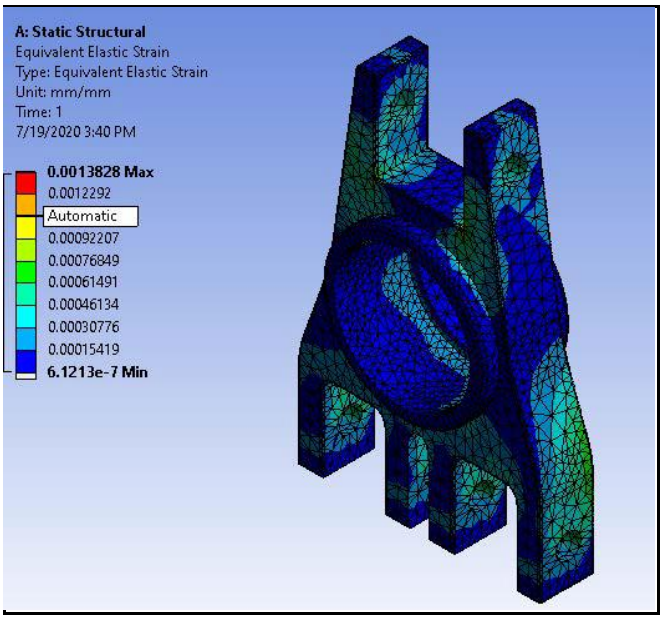


Figure 12: Equivalent Elastic Strain

Excellent	Very Good	Acceptable	Bad	Unacceptable
0.03 - 9.0	9.0 - 26.66	26.66- 44.41	44.41 - 62.16	62.16 - 71.0

REAR KNUCKLE ANALYSIS CONCLUSION

Sr. No.	Parameters	Values Obtained
1	Maximum Deformation	0.10 mm
2	Von-mises stresses	71 MPa
3	Equivalent Elastic Strain	0.0013
4	Factor of safety	3.5

- So, we did various analysis on knuckle like
    1. Max equivalent stress
    2. Total Deformation
    3. Von Misses stress analysis
    4. Von Misses strain analysis
- Here, while testing we applied various forces like
    1. Drop force = 8000 N
    2. Lateral force = 2185.86 N
    3. Longitudinal force = 816.652N
    4. Bump force = 3312 N
    5. Vehicle's weight = 690 N
- After performing the analysis mentioned above we found that
    1. Factor of safety = 3.5
    2. Von Misses stress = 71 MPA
    3. Max Deformation = 0.0013
    4. Equivalent Elastic Strain = 0.0013
- And after all the analysis the values we got were excellent.

3.2 WHEEL HUB

The wheel hub allows the wheel to rotate and mounts to the steering knuckle. It contains the wheel bearings and in a front wheel drive car connects to the axle shaft to also drive the front wheel. Hence, analysis is done to ensure the structure is ready to be used without any drawbacks.

Fatigue analysis simulates repetitive loading on the hub. Fatigue analysis on the basis of stress test was performed which indicates the total loading cycles sustained by the hub before failure. The results obtained showed the safe deformation, alternating stress and number of cycles values sustained by the knuckle. The analysis is also done graphically which signifies the stress ratio. The material selected is Aluminium 6063 T6.

3.2.1 FRONT WHEEL HUB

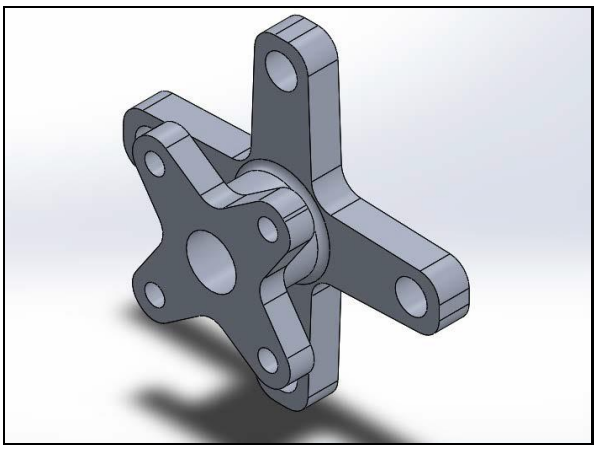


Figure 13: Front Wheel Hub CAD Model

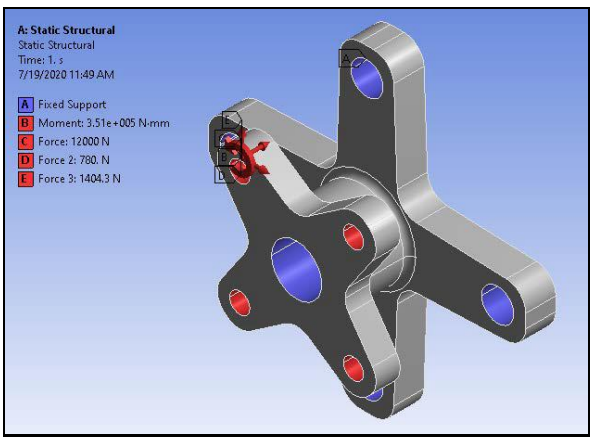


Figure 14: Front Wheel Hub with forces and constraints

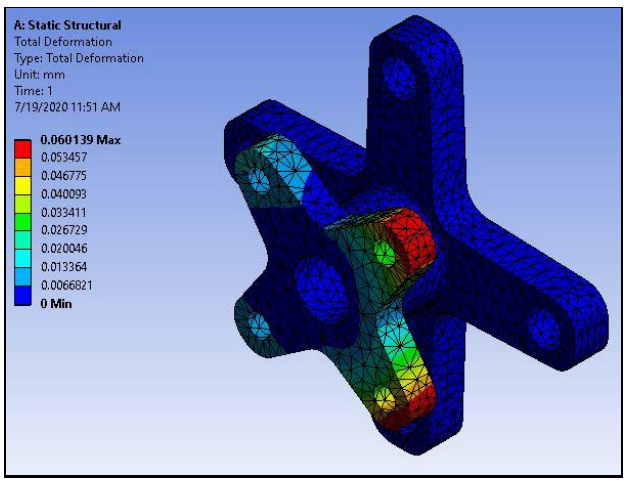


Figure 15: Maximum Deformation

Excellent	Very Good	Acceptable	Bad	Unacceptable
0 - 0.02	0.02 - 0.03	0.03 - 0.04	0.04 - 0.05	0.05 - 0.06

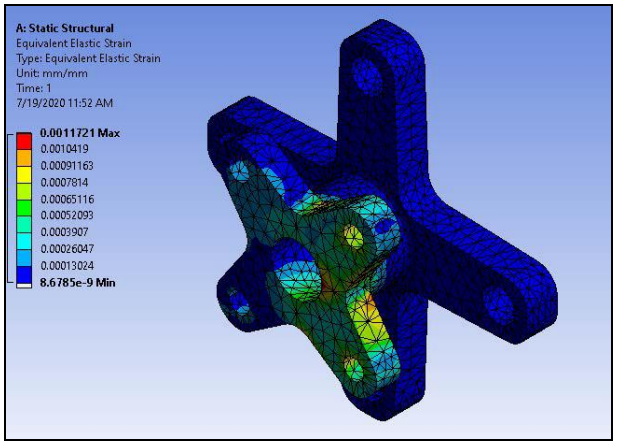


Figure 16: Equivalent Elastic Strain

Excellent	Very Good	Acceptable	Bad	Unacceptable
0.13-0.4	0.4-0.65	0.65-0.78	0.78-0.91	0.91-1.17

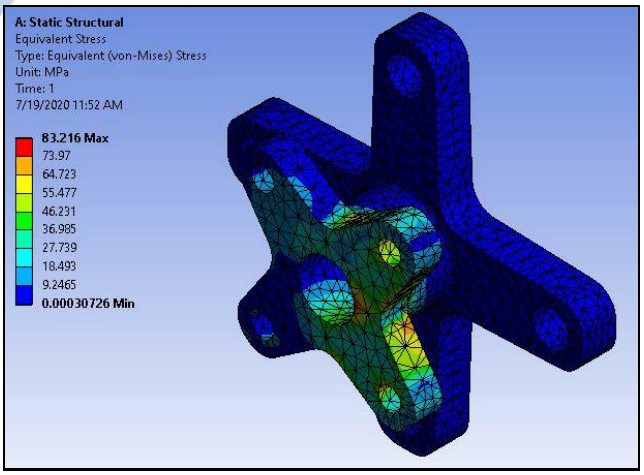


Figure 17: Von-Mises Stress

Excellent	Very Good	Acceptable	Bad	Unacceptable
0.0003-18.5	18.5-36.98	36.98-55.5	55.5-74	74-83.25

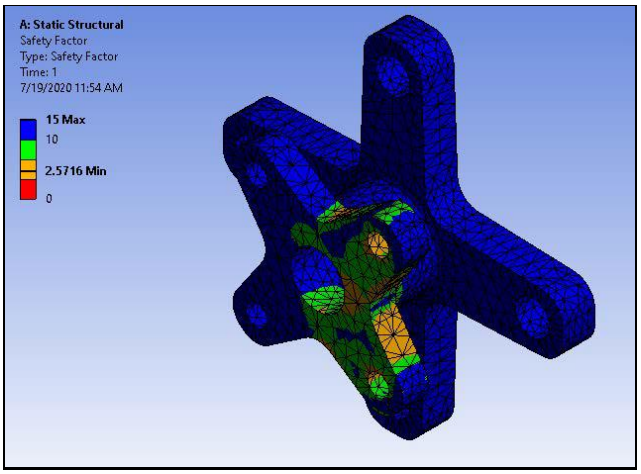


Figure 18 : Factor of Safety

Unacceptable	Acceptable	Excellent
0-2.5	2.5-10	10-15

Sr. No.	Parameters	Values Obtained
1	Maximum Deformation	0.06 mm
2	Von-mises stresses	83.22 MPa
3	Equivalent Elastic Strain	0.0011 mm/mm
4	Factor of safety	2.57

3.2.2 FATIGUE ANALYSIS OF FRONT WHEEL HUB

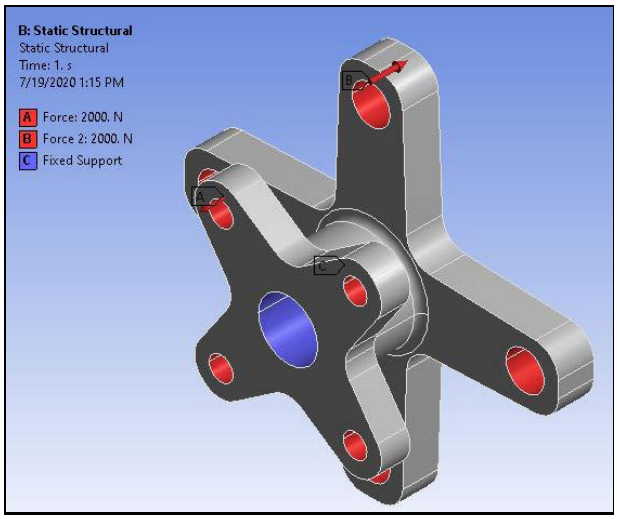


Figure 19: Front Wheel Hub with forces and constraints for fatigue analysis.

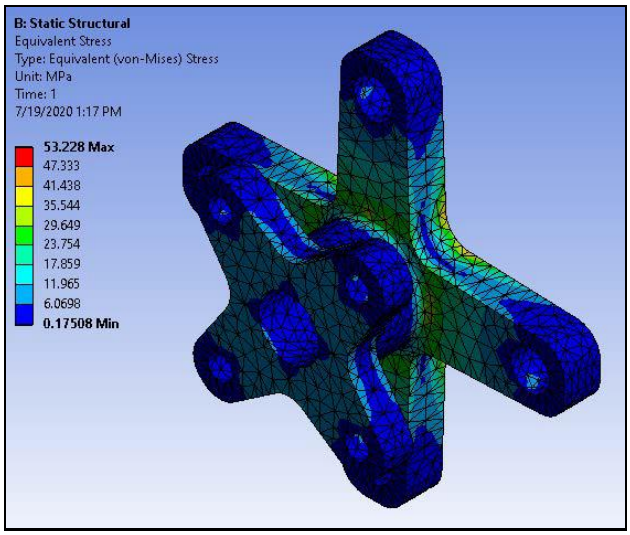


Figure 20: Von-Mises Stress for fatigue analysis

LIFE OF FRONT HUB

- As we can see from the table shown below the maximum stress the component (FRONT HUB)
  can sustain is 275.8 MPA with undergoing only 1700 cycles before failing.
- As for the minimum stress it can sustain 82.74 MPA with undergoing 1E+08 cycles before failing.
- But, according to S-N curve of a material if the stress applied to a component of that material is less than its minimum stress the component will sustain infinite cycles

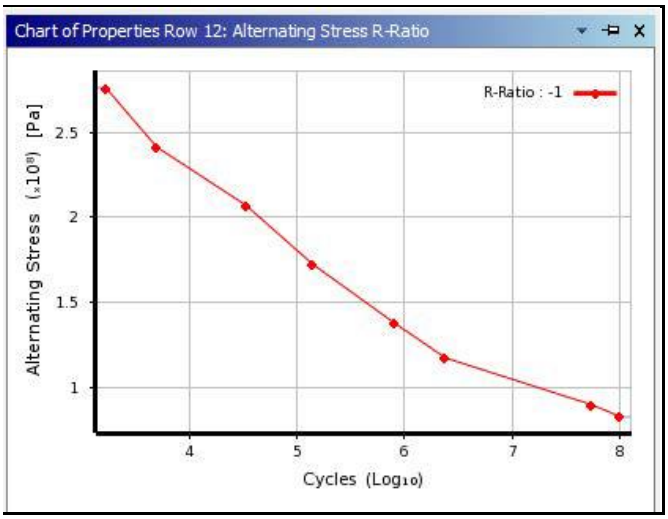


Figure 21:N CURVE

- As we can see in above image that the stress applied to hub is 53.228 MPA which is less than the minimum stress in table which is 82.74 MPA.
- So we concluded that after the fatigue analysis of our front hub. Our hub can endure infinite number of cycles.

STRESS TABLE: -

	B	C
1	Cycles	Alternating Stress (MPa)
2	1700	275.8
3	5000	241.3
4	34000	206.8
5	1.4E+05	172.4
6	8E+05	137.9
7	2.4E+06	117.2
8	5.5E+07	89.63
9	1E+08	82.74
*		

Figure 22:Max and Min stress corresponding to their life cycles table

LIFE OF FRONT HUB – INFINTE

STRESS (MPA)	LIFE (CYCLES)
MAXIMUM = 275.8	1700
MINIMUM = 82.74	1E+08
ACTUAL = 53.228	INFINITE

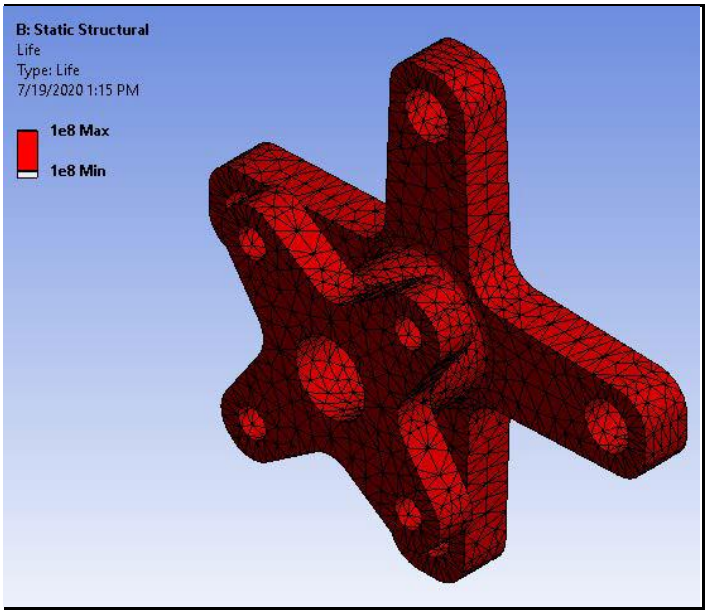


Figure 23: Life of Front Wheel Hub

3.2.3 REAR WHEEL HUB

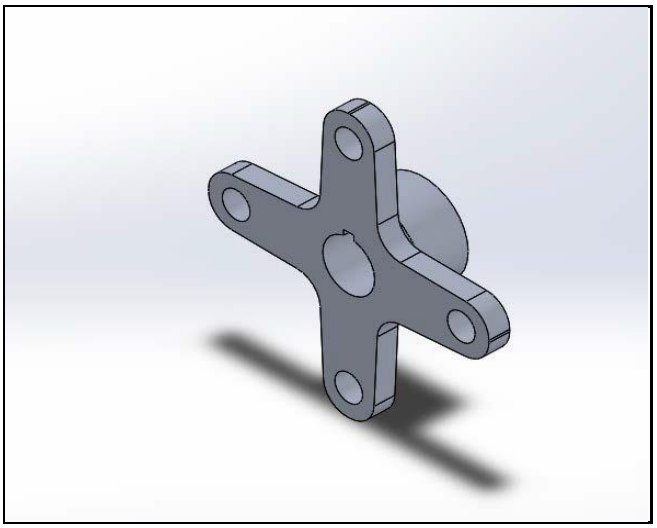


Figure 24: Rear Wheel Hub CAD Model

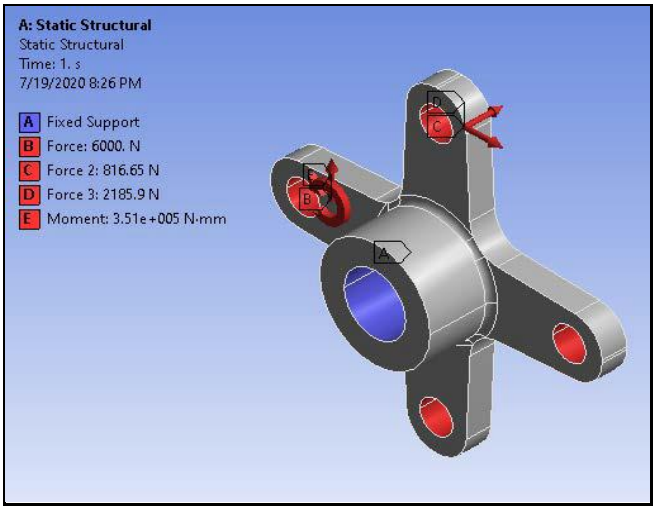


Figure 25: Rear Wheel Hub with forces and constraints

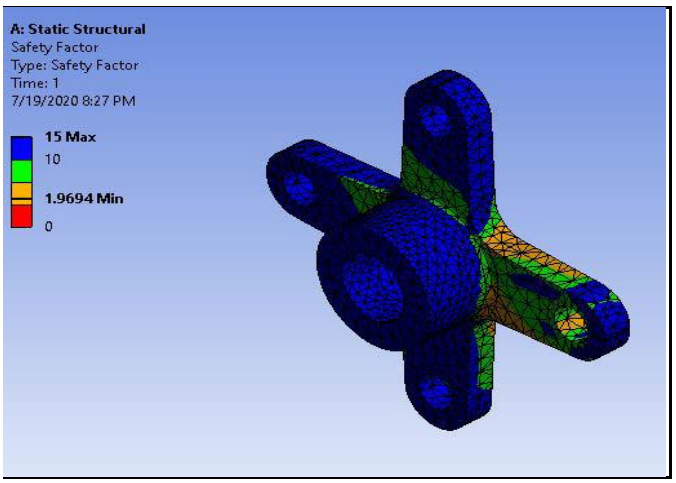


Figure 26: Factor of Safety

Unacceptable	Acceptable	Excellent
0-1.97	1.97-10	10-15

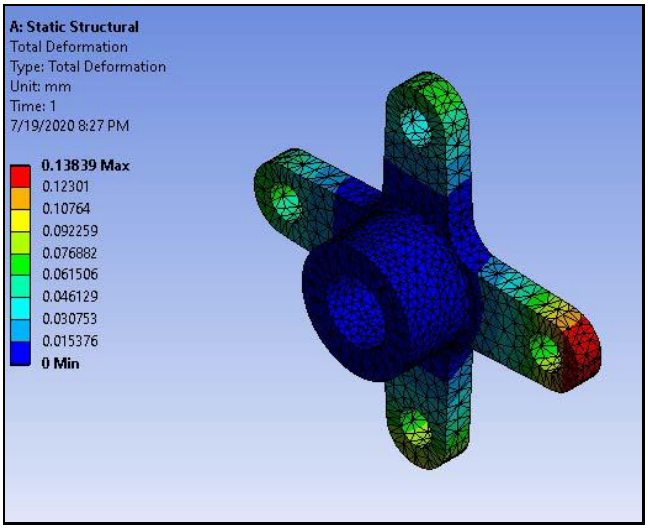


Figure 27: Maximum Deformation

Excellent	Very Good	Acceptable	Bad	Unacceptable
0 - 0.03	0.03 - 0.06	0.06 - 0.09	0.09 - 0.11	0.11 - 0.13

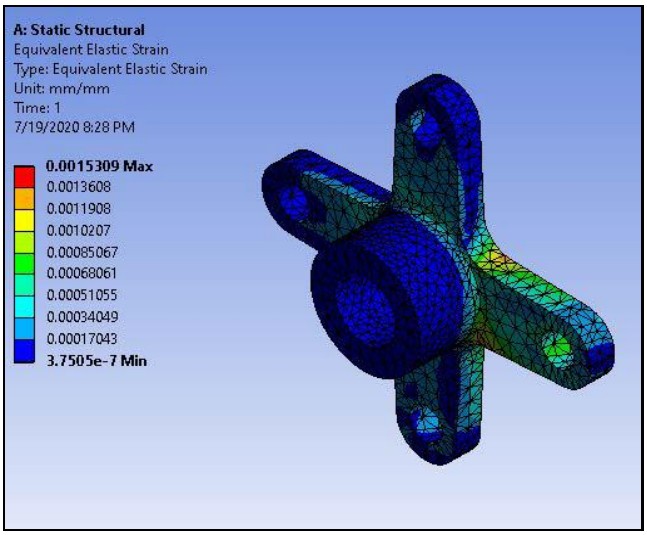


Figure 28: Equivalent Elastic Strain

Excellent	Very Good	Acceptable	Bad	Unacceptable
3.7e-7 - 0.17	0.17-0.51	0.51-0.85	0.85-1.19	1.19-1.53

\

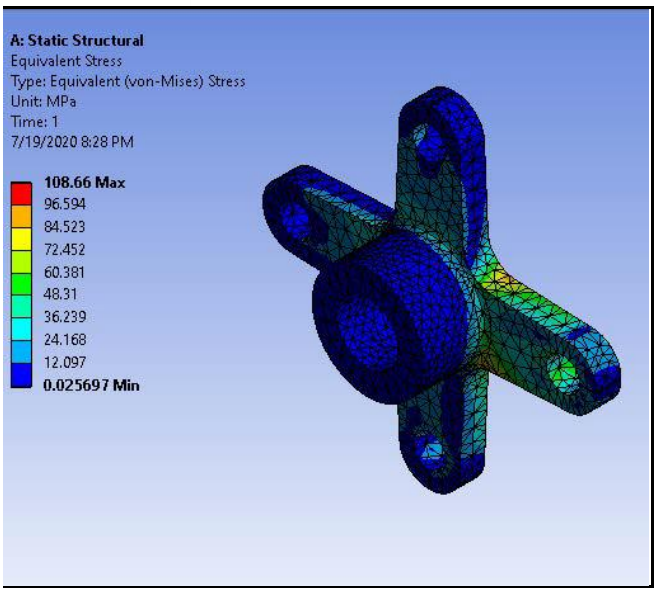


Figure 29: Von-Mises Stress

Excellent	Very Good	Acceptable	Bad	Unacceptable
0.02-24.17	24.17-48.31	48.31-72.45	72.45-96.6	96.6-108.66

Sr. No.	Parameters	Values Obtained
1	Maximum Deformation	0.14 mm
2	Von-mises stresses	108.66 MPa
3	Equivalent Elastic Strain	0.0015 mm/mm
4	Factor of safety	1.97

3.2.4. FATIGUE ANALYSIS OF REAR WHEEL HUB

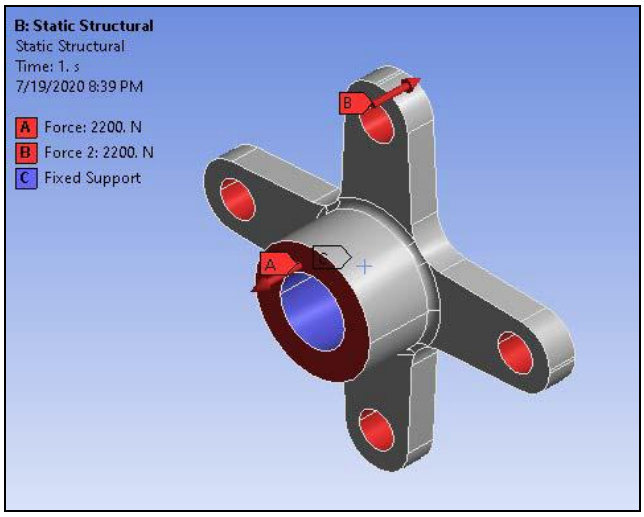


Figure 30 : Front Knuckle with forces and constraints

3

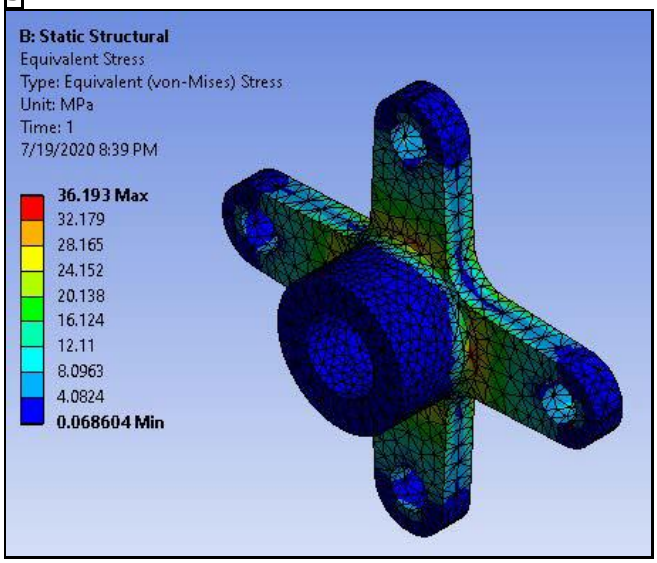


Figure 31: Von-Mises Stress

LIFE OF REAR HUB

- As we can see from the table shown below the maximum stress the component (rear hub) can sustain is 275.8 MPA with undergoing only 1700 cycles before failing.
- As for the minimum stress it can sustain 82.74 MPA with undergoing 1E+08 cycles before failing.
- But, according to S-N curve of a material if the stress applied to a component of that material is less than its minimum stress the component will sustain infinite cycles.

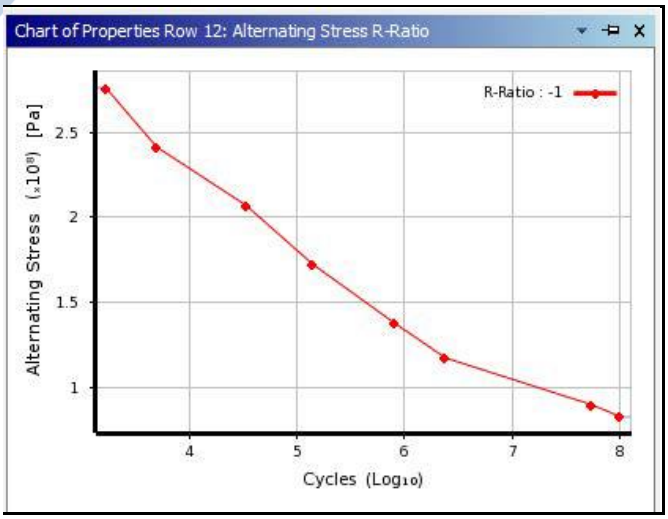


Figure 32:N CURVE

- As we can see in above image that the stress applied to hub is 53.228 MPA which is less than the minimum stress in table which is 82.74 MPA.
- So we concluded that after the fatigue analysis of our rear hub. Our hub can endure infinite number of cycles.

STRESS TABLE -

	B	C
1	Cycles	Alternating Stress (Pa)
2	1700	2.758E+08
3	5000	2.413E+08
4	34000	2.068E+08
5	1.4E+05	1.724E+08
6	8E+05	1.379E+08
7	2.4E+06	1.172E+08
8	5.5E+07	8.963E+07
9	1E+08	8.274E+07
*		

LIFE OF FRONT HUB – INFINTE

STRESS (MPA)	LIFE (CYCLES)
MAXIMUM = 275.8	1700
MINIMUM = 82.74	1E+08
ACTUAL = 53.228	INFINITE

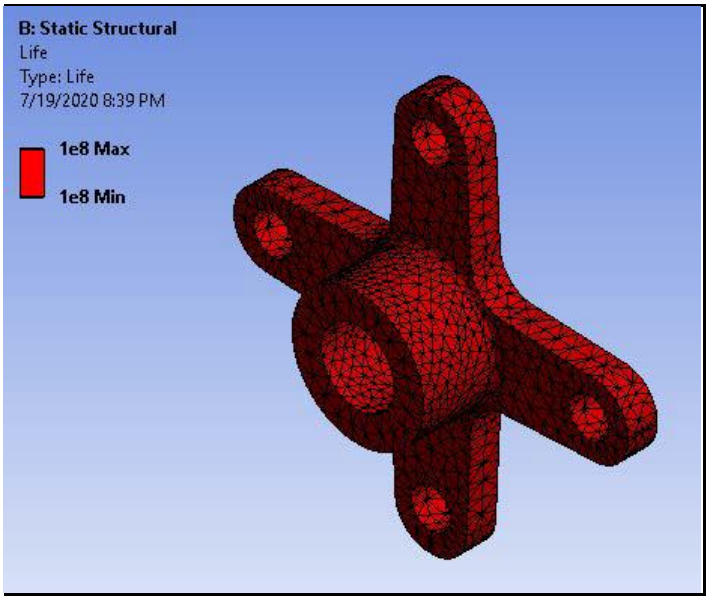


Figure 33: Life of Rear Wheel Hub

3.3 TRIPOD PLATE

The height of the tripod plate is 80 mm which helps achieve enough leverage to overcome the friction. The material selected is Mild Steel.

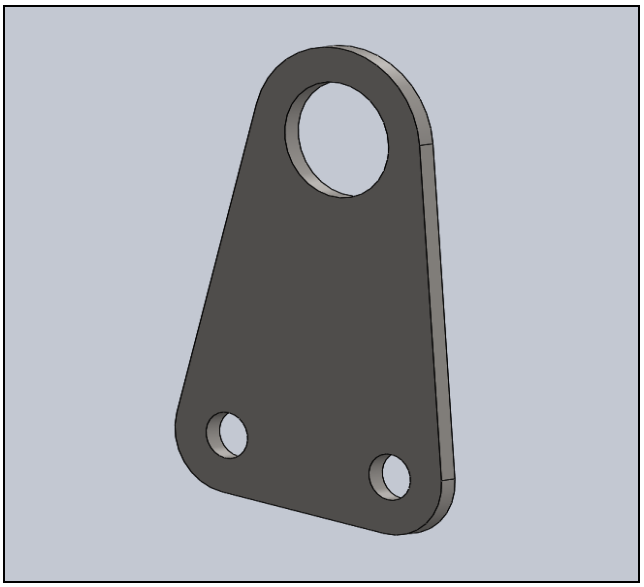


Figure 34: Tripod Plate CAD Model

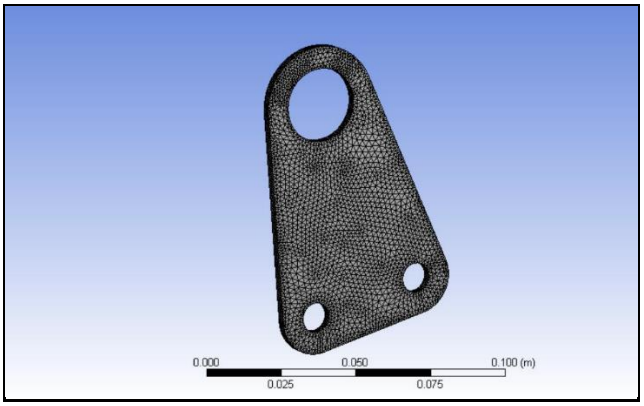


Figure 35: Tripod Plate meshed CAD Model

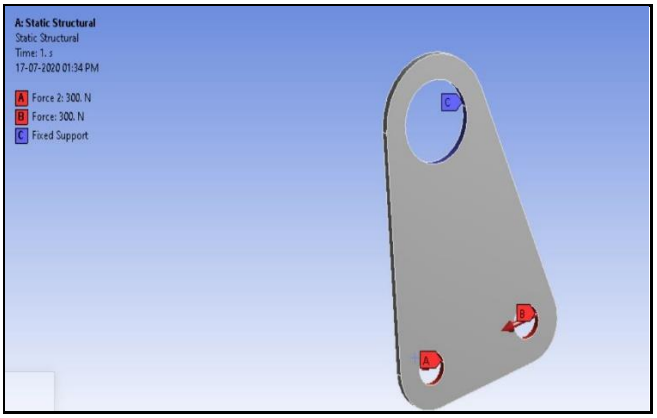


Figure 36: Tripod with forces and constraints

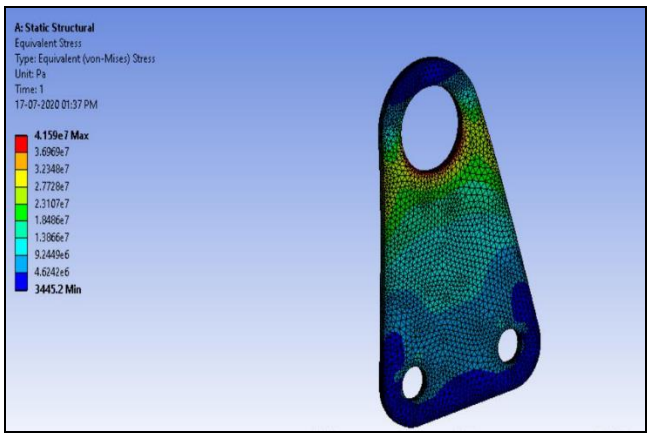


Figure 37: Von-Mises Stress

Excellent	Very Good	Acceptable	Bad	Unacceptable
3445.2-4.62	4.62e6 - 1.38e6	1.3e7 - 2.3e7	2.3e7 - 3.2e7	3.2e7 - 4.2e7

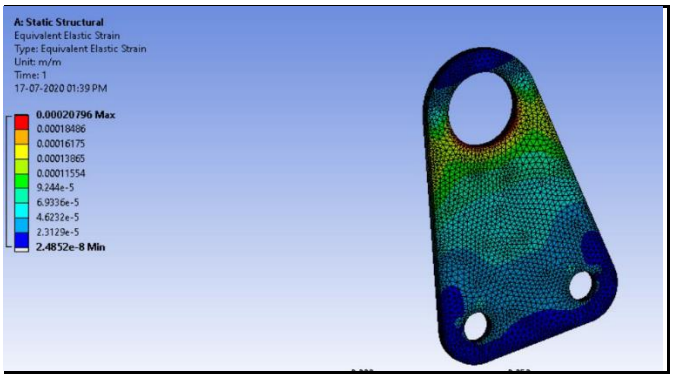


Figure 38: Equivalent Elastic Strain

Excellent	Very Good	Acceptable	Bad	Unacceptable
2.4e-8 - 4.6e-5	4.6e-5 - 9.2e-5	9.2e-5 - 0.0001	0.0001 - 0.0002	0.0002- 0.00021

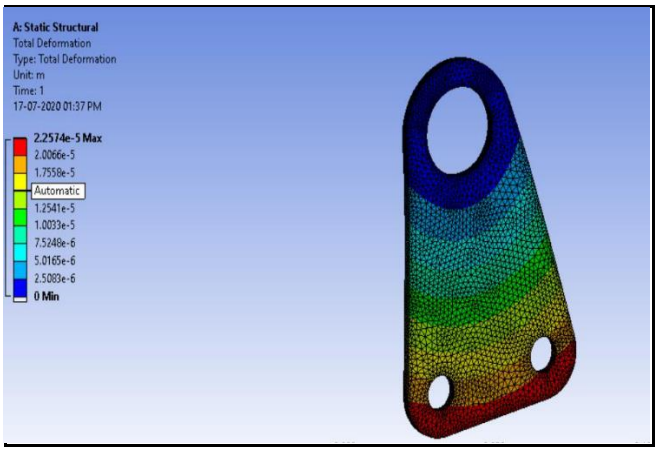


Figure 39: Maximum Deformation

Excellent	Very Good	Acceptable	Bad	Unacceptable
0-5e-6	5e-6 - 1e-7	1e-7 - 1.25e-7	1.25e-7 - 1.7e-5	1.7e-5 - 2.26e-5

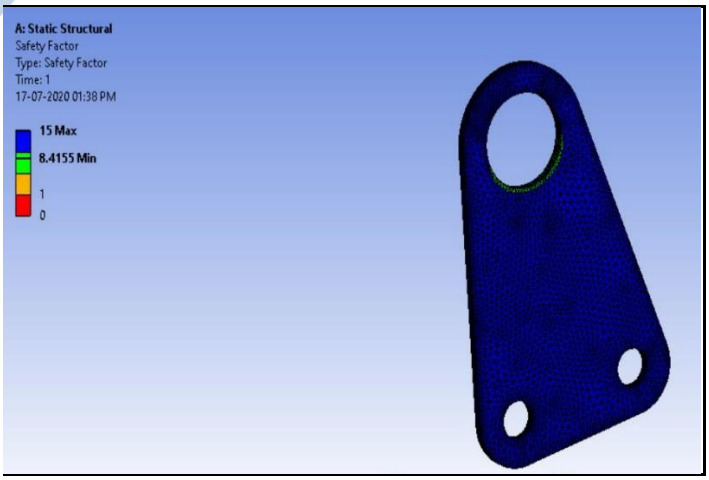
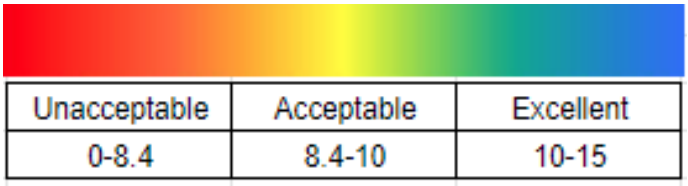


Figure 40: Factor of Safety



Unacceptable	Acceptable	Excellent
0-8.4	8.4-10	10-15

- After performing the analysis mentioned above we found that
  1. Factor of safety = 8.41
  2. Maximum deformation = 2.26E-5 m
  3. Von Misses stress = 41.6 MPA
  4. Equivalent Elastic Strain = 0.0002
- And after all the analysis the values we got were sometimes acceptable and sometimes excellent

TRIPOD ANALYSIS CONCLUSION

Sr. No.	Parameters	Values Obtained
1	Maximum Deformation	2.26e-5 m
2	Von-mises stresses	4.16e7 Pa
3	Equivalent Elastic Strain	0.0002 m/m
4	Factor of safety	8.4

- So, we did various analysis on knuckle like
  1. Max equivalent stress
  2. Total Deformation
  3. Von Misses stress analysis
  4. Von Misses strain analysis
- Here, while testing we applied various forces like
  1. Bump force = 1600 N
  2. Lateral force = 702.45 N
  3. Longitudinal force = 389.92 N
  4. Tripod force = 100 N

3.4 TIE ROD

The tie rod design has circular rod, threaded part, outer and inner end which will determine the buckling displacement.
The material selected is Mild Steel.

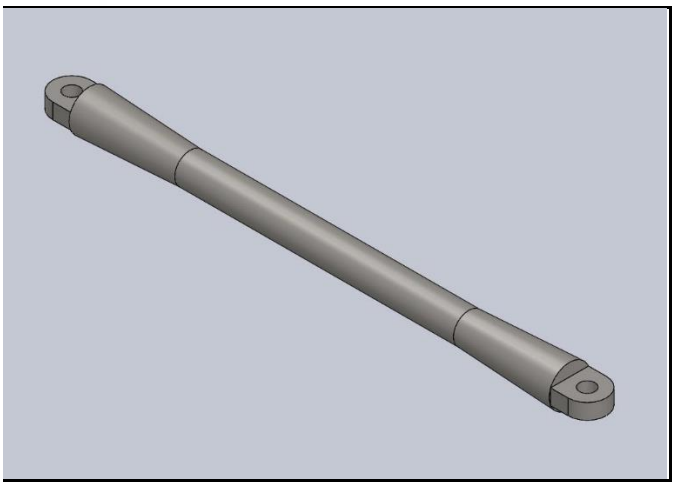


Figure 41: Tie Rod CAD Model

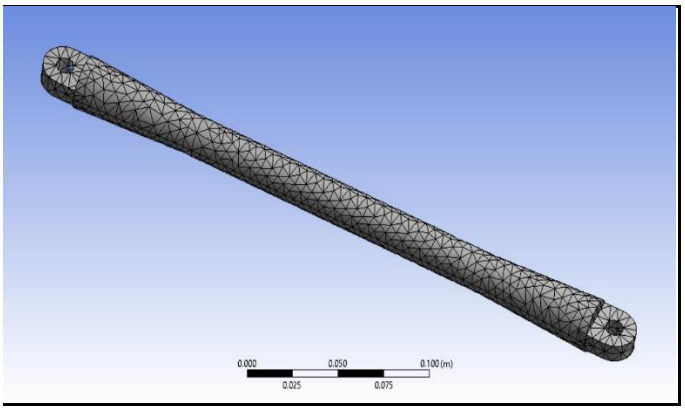


Figure 42: Tie Rod meshed CAD Model

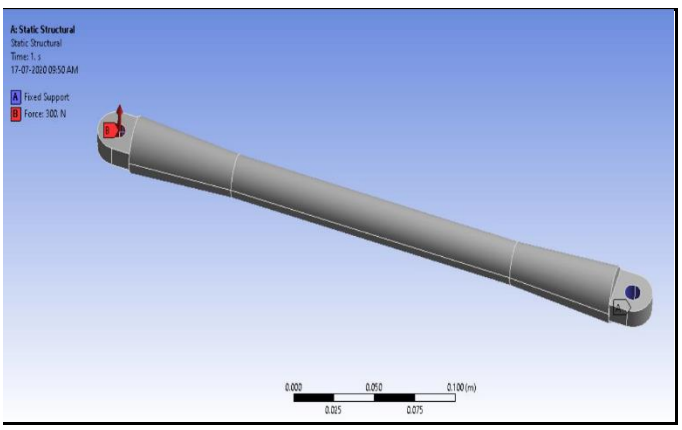


Figure 43: Tie Rod with forces and constraints

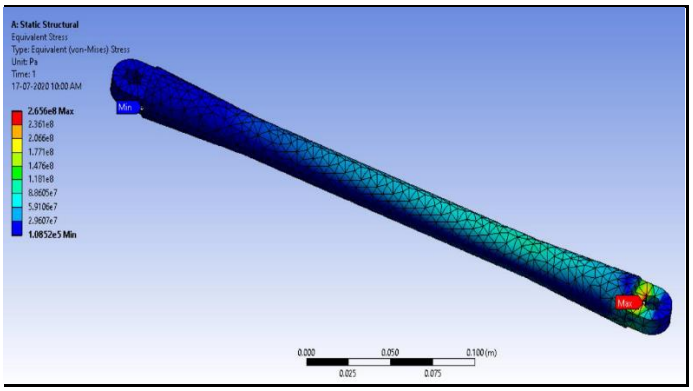


Figure 44 : Von-Mises Stress

Excellent	Very Good	Acceptable	Bad	Unacceptable
1.08e5 - 5.9e7	5.9e7 - 1.2e8	1.2e8 - 1.5e8	1.5e8 - 2.1e8	2.1e8 - 2.6e8

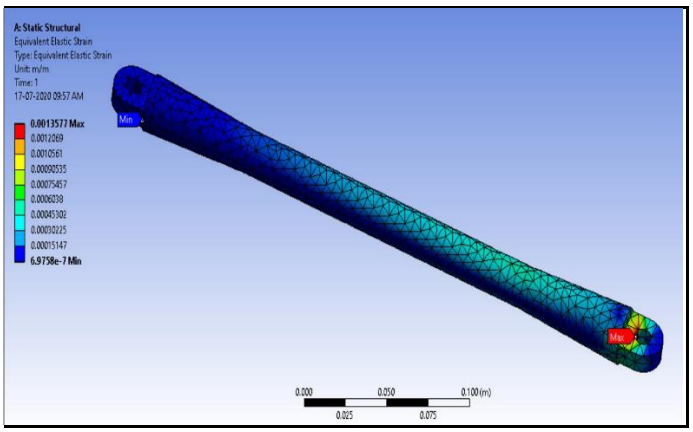


Figure 45: Equivalent Elastic Strain

Excellent	Very Good	Acceptable	Bad	Unacceptable
6.9e-7 - 0.3	0.3 - 0.6	0.6 - 0.9	0.9 - 1.2	1.2 - 1.3

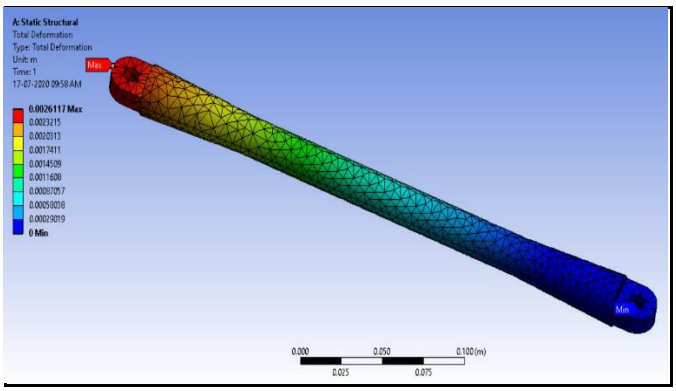


Figure 46: Maximum Deformation

Excellent	Very Good	Acceptable	Bad	Unacceptable
0 - 0.0005	0.0005-0.001	0.001-0.0017	0.0017-0.002	0.002-0.0026

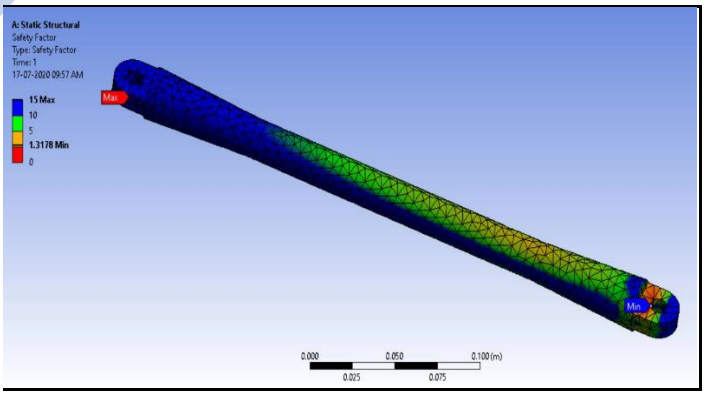
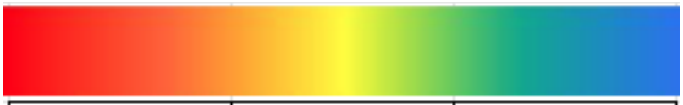


Figure 47: Factor of Safety



Unacceptable	Acceptable	Excellent
0-1.31	1.31-10	10-15

TIEROD ANALYSIS CONCLUSION

Sr. No.	Parameters	Values Obtained
1	Maximum Deformation	0.003 m
2	Von-mises stresses	2.65 Mpa
3	Equivalent Elastic Strain	0.0013 m/m
4	Factor of safety	1.32

- So, we did various analysis on knuckle like
  1. Max equivalent stress
  2. Total Deformation
  3. Von Misses stress analysis
  4. Von Misses strain analysis
- Here, while testing we applied various forces like
  1. Drop force = 2000 N
  2. Lateral force = 702.145 N
  3. Longitudinal force = 389.92 N
  4. Bump force = 1600 N
  5. Tie rod force = 300 N

- After performing the analysis mentioned above we found that
  1. Factor of safety = 1.32
  2. Maximum deformation = 0.003mm
  3. Von Misses stress = 2.65 MPA
  4. Equivalent Elastic Strain = 0.0013
- And after all the analysis the values we got were sometimes acceptable and sometimes excellent

FINAL CONCLUSION

The forces applied in the above tests and the factor of safety obtained is tabulated below:

Sr. No.	Name of Test	Factor of Safety
1	Front Knuckle	1.9
2	Rear Knuckle	3.5
3	Front Wheel Hub	2.57
4	Rear Wheel Hub	1.97
5	Tripod Testing	8.4
6	Tierod Testing	1.32