Dr. D. Y. Patil Institute of

Technology, Pimpri, Pune - 18.

Team The Interceptors

Departmental Design Reports

Wheel Assembly Department

Weight of vehicle = 285kg

Height of CG= 228.689mm

Weight distribution weight =45:55

Weight at front= $\frac{128.25}{2}$ **=64.125 kg**

Weight at rear = $\frac{156.75}{2}$ **=78.375 kg**

Trak width front =1185.4mm

Track width Rear =1125.4mm

Wheelbase=1585mm

Turning Radius =3500mm

Weight of tire=3.6kg weight of rim = 2.80 kg

Constant Speed at turn=40kmph

V= 11.111

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1) Introduction

Formula Student

Formula Student is an engineering competition. Students are pushed to put in practice the

engineering and management capabilities they have learned throughout their academic path, as well as

further developing them in a practical way. Teams are encouraged to design, build and race a formula

prototype vehicle, built according to a specific set of rules renewed and published every year. Over time

the competition has grown and became a perfect testing ground for new concepts and ideas, allowing

students to assess real world problems in an academic environment.

During the competition events, design decisions involved in the project and the performance of

the cars are evaluated, allowing the participants to showcase their skills to renowned judges in the

engineering, motorsport and automotive industries. The running prototypes are evaluated dynamically

in four separate events that try to push the vehicles to the limits of their capabilities:

• Acceleration: consisting in a straight line with a length of 75m;

• Skid-pad: consisting in a figure-of-eight track;

• Autocross: consisting of a single lap around a handling track with a typical length of 1km;

• Endurance & Fuel Economy: consisting of 22 laps around a closed circuit, usually similar to the

one of autocross.

2)Aim and Objective

The project is to design and fabricate part of the suspension system for Team The Interceptors new FS race car. This thesis is covers the parts that connect between the a-arm (double wishbone) and the wheel. Those parts include the front and rear uprights, wheel hubs and brake system at the wheels. That meant some parts were built with higher factor of safety than needed to prevent any critical structural failures. Since the one of key elements in race car design is to keep unsprung mass as low as possible the aim of the design is to be lightweight yet reliable and easily maintained while maintaining structural integrity .

Department Name : Wheel Assembly

Part Name :

1) Wheel knuckle

2) Wheel hub

3) Tapered Roller bearing

4) Ball bearing

5) Lug bolt

Part Use :

1) Wheel knuckle : The part which contains the wheel hub or spindle, and attaches to the suspension and steering components.

2) Wheel hub : Keeps your wheel attached to your vehicle and allows the wheels to freely turn enabling you to safely steer.

3) Tapered Roller bearing : Rolling element bearings that can support axial forces (i.e., they are good thrust bearings) as well as radial forces.

4) Ball bearing : Use to reduce rotational friction and support radial and axial loads.

5) Lug bolt : Used to secure a wheel to threaded wheel studs and thereby to a vehicle's axles.

Rule satisfaction

There are several constraints that must be satisfied to when designing the wheel assembly – Formula SAE (FSAE) rules. The rules for the FSAE competition act as a constraint on the design of the wheel assembly. All designs must conform to the specified requirements to be eligible for competition

Empty Cell	Name	Description
FSAE rules	T6.1.2	all A-arm and steering connection points are visible
	T6.5.2	e steering will be placed on the front uprights and must ensure the tyres do not come into contact with the suspension, body or frame
	T11.1 and T11.2	use 8.8 class bolts or higher; fasteners will also be in double shear
	T7.1	The braking system acts on all four wheels where the brake assembly is attached to the front wheel assembly. The rear drive shaft will hold the brake assembly to brake the rear wheels.

Material selection

Optimum material selection with cost of material and material properties is done. The material selected should handle the force faced on wheel assembly during cornering, turning, acceleration and braking. the material should also be cost efficient and light weight

The material decided to be taken is aluminium 6082 for wheel knuckle and it has high strength to weight ratio and better fatigue properties.

Material properties

Aluminium 6082 t6	**Density- 2.70 g/cc**
Aluminium 6082 t6	**Tensile strength- 310 mpa**
Aluminium 6082 t6	**Yield strength-260 mpa**
Aluminium 6082 t6	**Melting point- 555 C**
Aluminium 6082 t6	**Youngs modulus 69**
Aluminium 6082 t6	**Poisson ratio 0.33**
Aluminium 6082 t6	**Shear modulus 26**

4) Final Iteration

Calculations :

Dynamic force calculation for knuckle

Weight of vehicle = 285kg

Height of CG= 228.689mm

Weight distribution weight =45:55

Weight at front= $\frac{128.25}{2}$ =64.125 kg

Weight at rear = $\frac{156.75}{2}$ =78.375 kg

Trak width front =1185.4mm

Track width Rear =1125.4mm

Wheelbase=1585hmm

Turning Radius =3500mm

Weight of tire=3.6kg weight of rim = 2.80 kg

Lateral Acceleration

Constant Speed at turn=40kmph = 11.111

r = 7.62

Ay= $\frac{V2}{r}$

=11.111 $\div$ 7.62

= 16.201m/s$^{2/}$9.81

=1.651 g

Lateral load Transfer

= (FW Lateral acceleration $\times$ CG $\div$front track

$=(128.25 \times 1.651 \times 228.689) \div 1185.4$

= 40.82 kg

Lateral Load transfer

$=(RW\ lateral\ acceleration \times cg) \div Rear\ track$

$=(156.75 \times 1.651 \times 228.689) \div 1125.4$

= 52.55 kg

Constant Speed at turn=40kmph

V = 11.111

t = 2.000

Longitudinal Acceleration:

=V $\div\ t$

$=11.111 \div 2.000$

=5.55 g

Longitudinal Load transfer:

$=(acceleration \times weight \times cg\ height) \div wheel\ base$

$=5.55 \times 142.5 \times 228.689 \div 1585$

=114.11 kg

Vertical force=m×a

=285 × 1.65

=470.25 N

Force on steering arm

$=load\ on\ one\ wheel \times g$

$= 64.125 \times 9.81$

= 629.06 N

Friction force

$= 0.6 \times force\ on\ steering\ arm$

=0.6 × 629.06

=377.436 N

Torque acting about steering axis

$=friction\ force \times scrub\ radius$

=629.06 × 5.4

=3396.924 N

Force acting on tie rod

= torque on steering axis/length of steering arm

= 3396.924 /48

= 70.769 N

Vertical force acting due to centrifugal couple

$= m \times v2 \times \frac{CG}{R^2} \times \ track\ width$

$=[285 \times (8.8)^2 * 228.689] \div 6 \times 1185.4$

=1131.30 N

Vertical load acting on each wheel Front

$= 64.125 \times 9.81$

.= 629.06 N

Vertical load acting on each wheel Rear:

$= 78.375 \times 9.81$

=768.85 N

Lateral force acting on one wheel

Velocity during cornering = 11.111m/s

Lateral acceleration=1.65 g

FOS= 1.5

Mv^2/r

$=[285 \times (11.111)^2] \div 3.5$

=10052.709 N

Force acting on wheel Front: 0.45×10052.709=4523.72 N

Force acting on one wheel Front

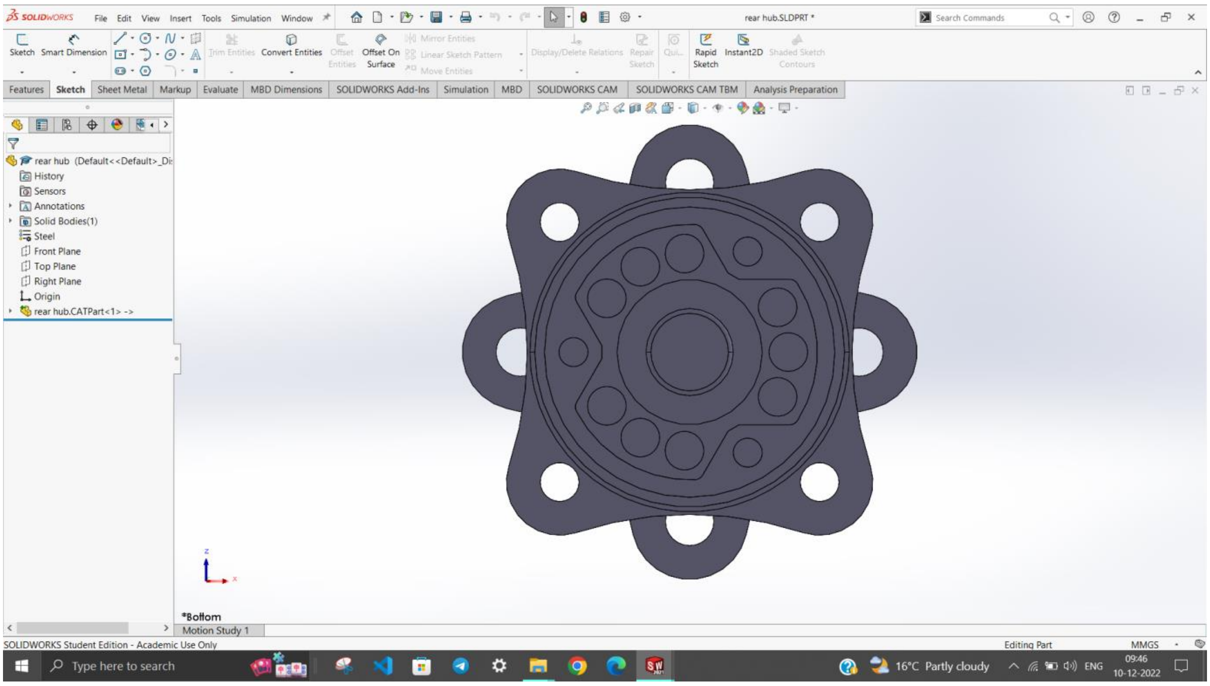
= 4523.72 ÷ 2 $= 2261.85$ × 1.5 = 3392.775 N

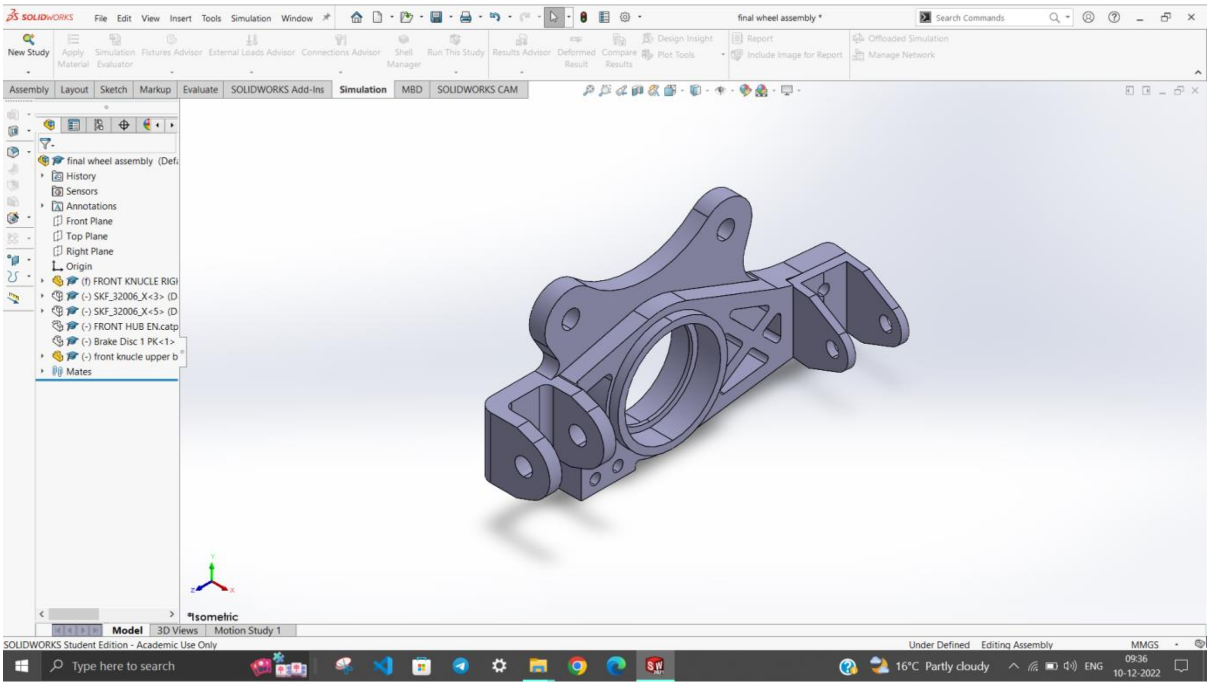
Force acting on one wheel Rear: 0.55 × 10052.709 = 5528.98 N

Force acting on one wheel Rear:

5528.98 ÷ 2 = 2764.49 × 1.5 = 4146.73 N

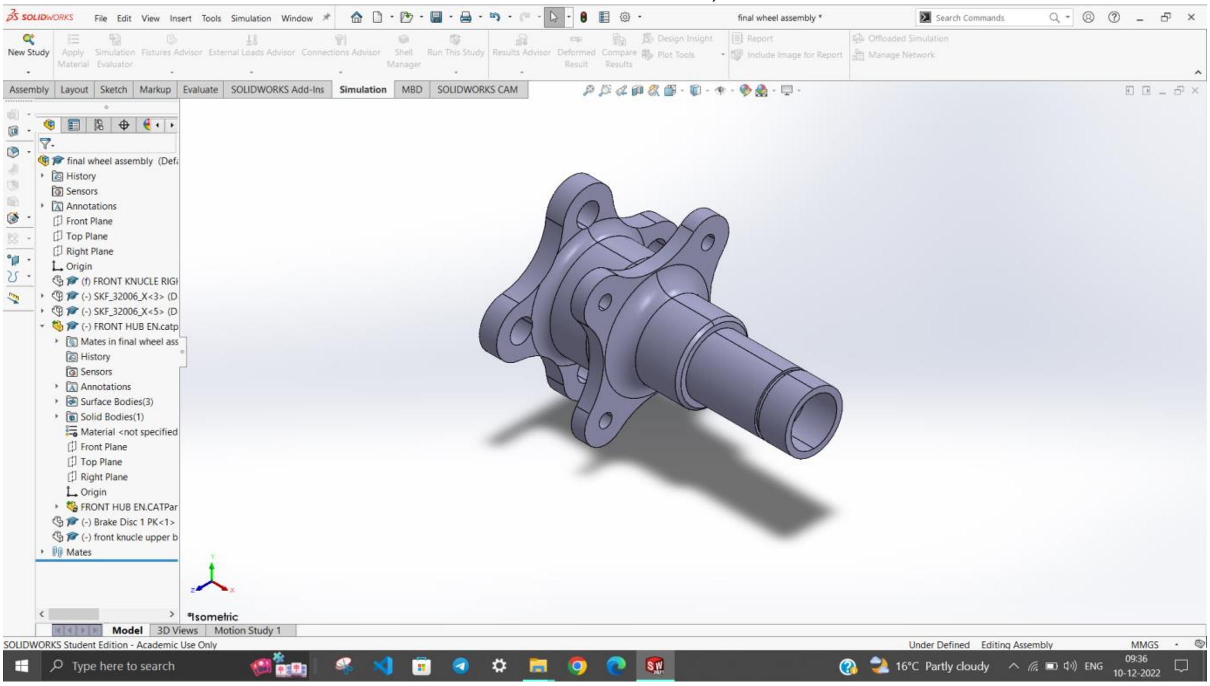
5)CAD Drawings :

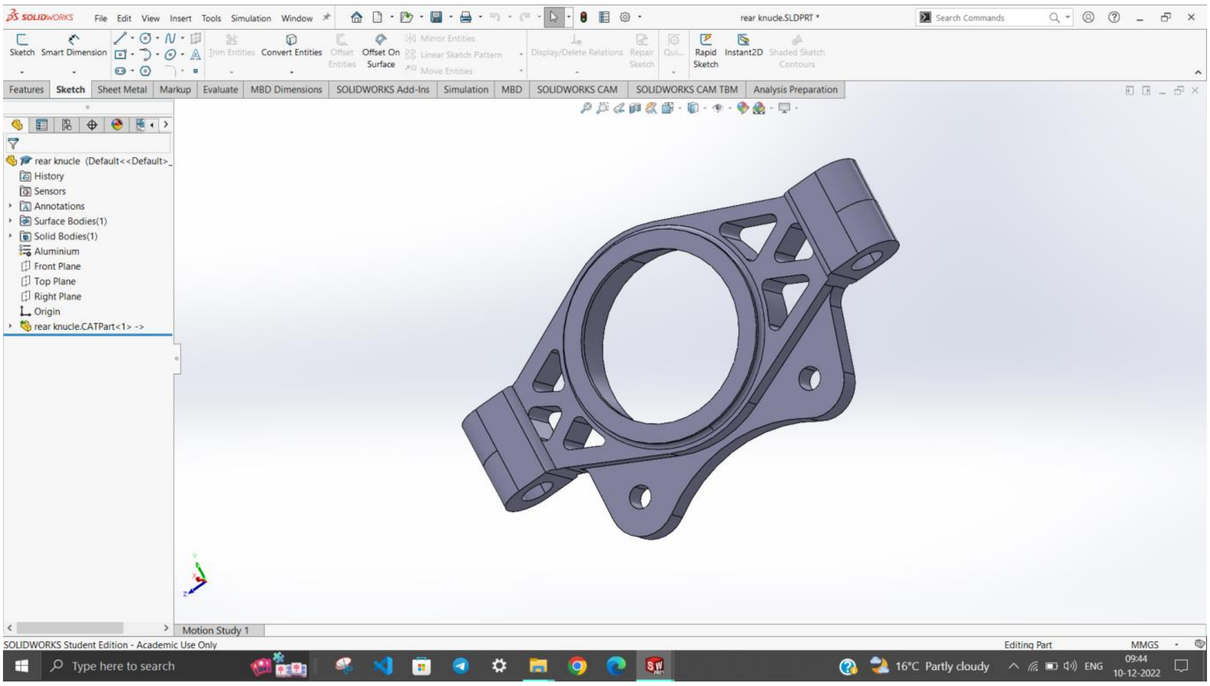




THE INTERCEPTORS

THE FORMULA STUDENT TEAM OF DIT, PIMPRI





THE INTERCEPTORS

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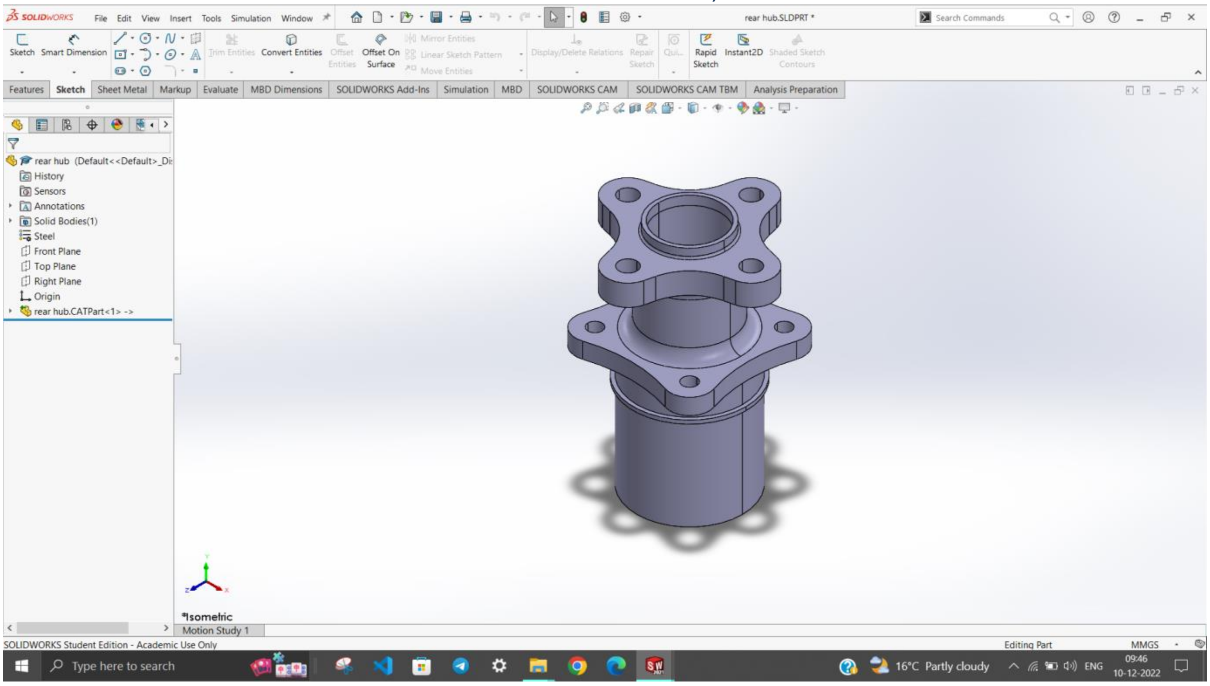
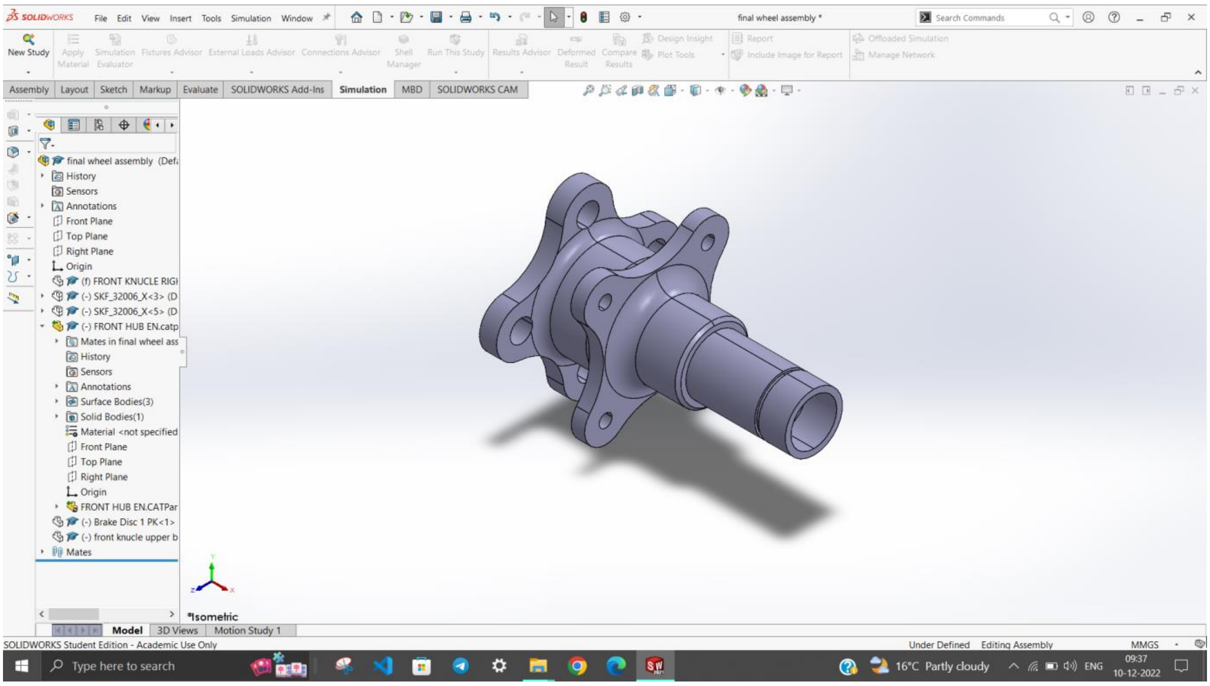
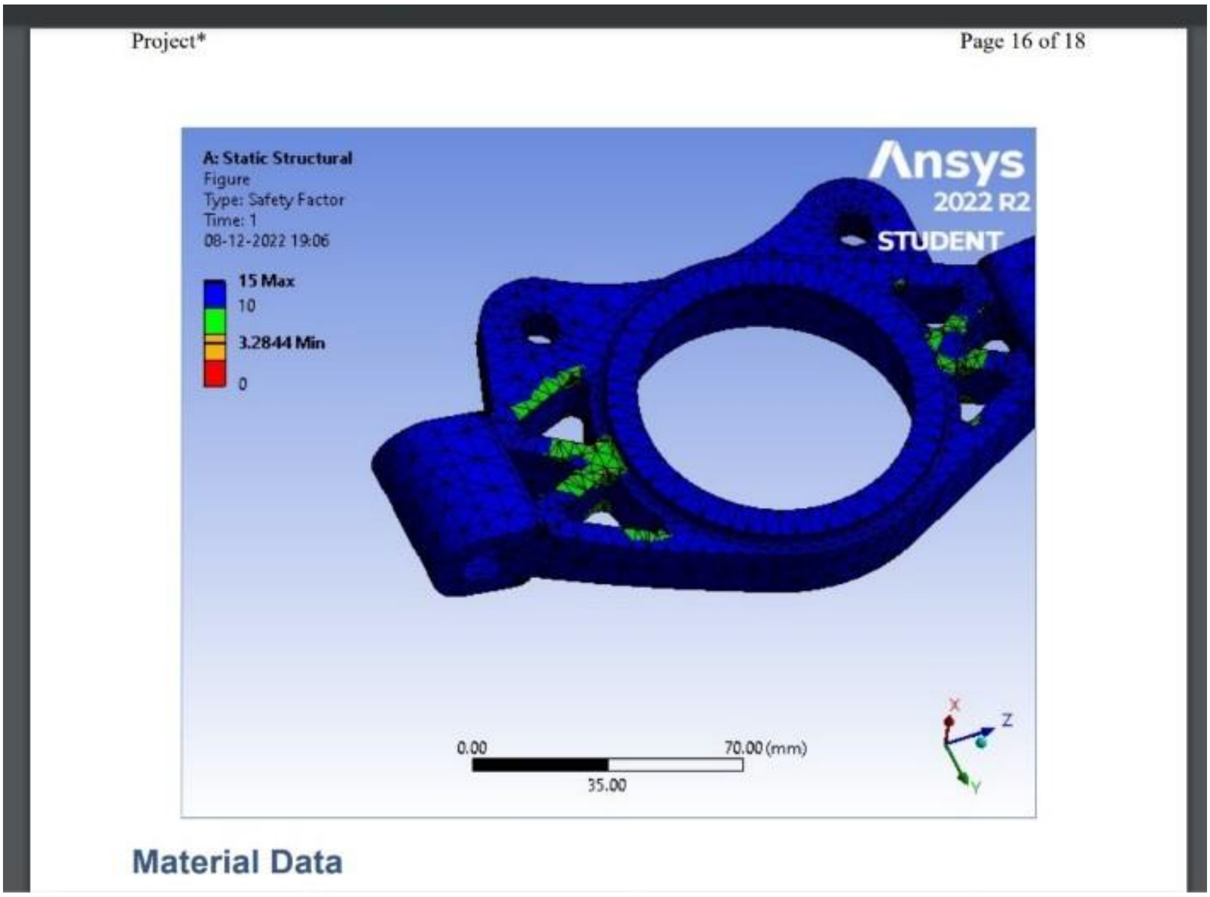




6)Simulation: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Material Data

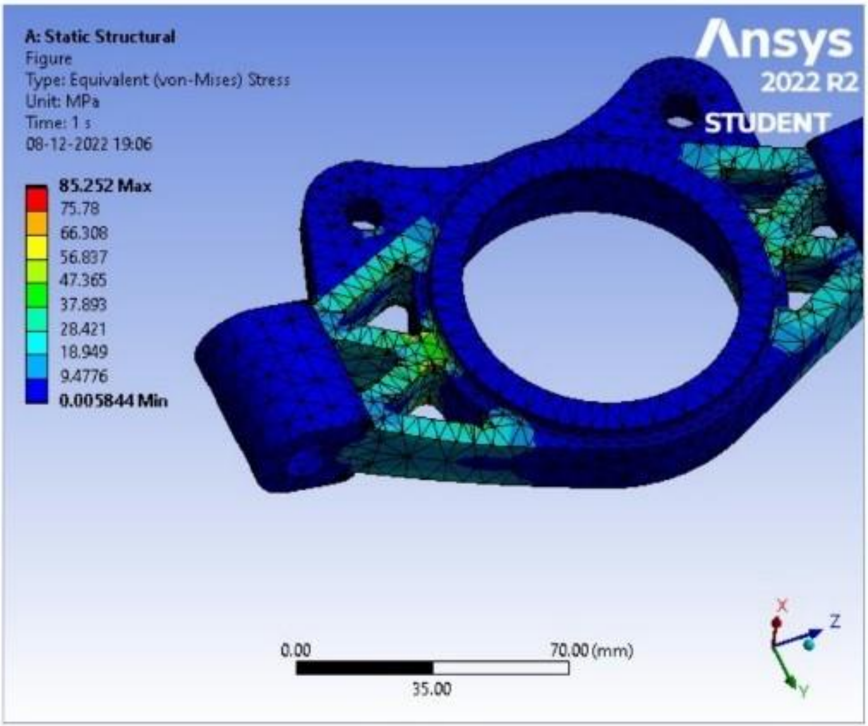


TABLE 17

Model (A4) > Static Structural (A5) > Solution (A6) > Stress Safety Tools

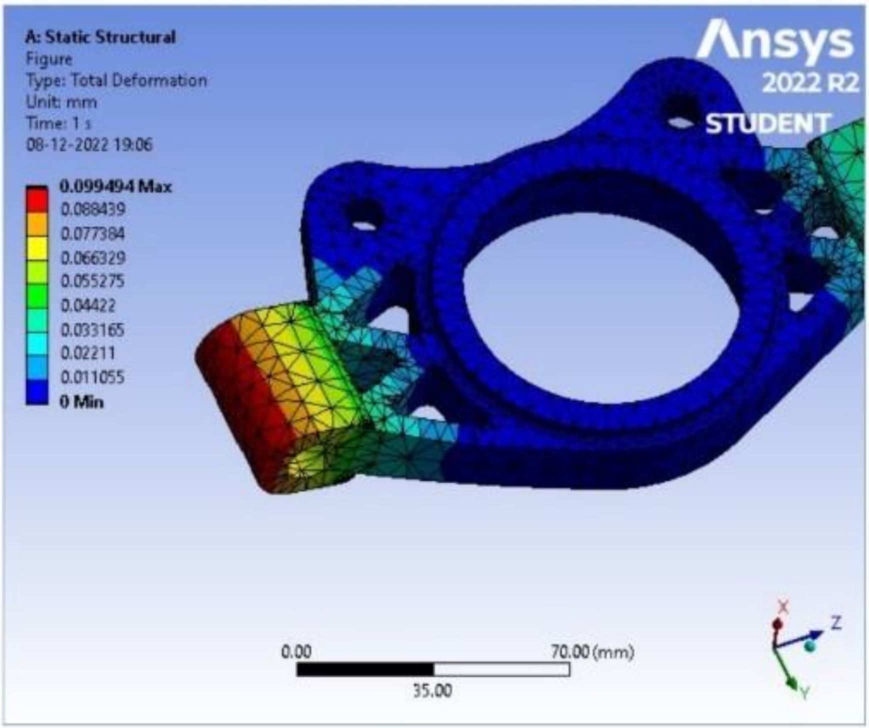
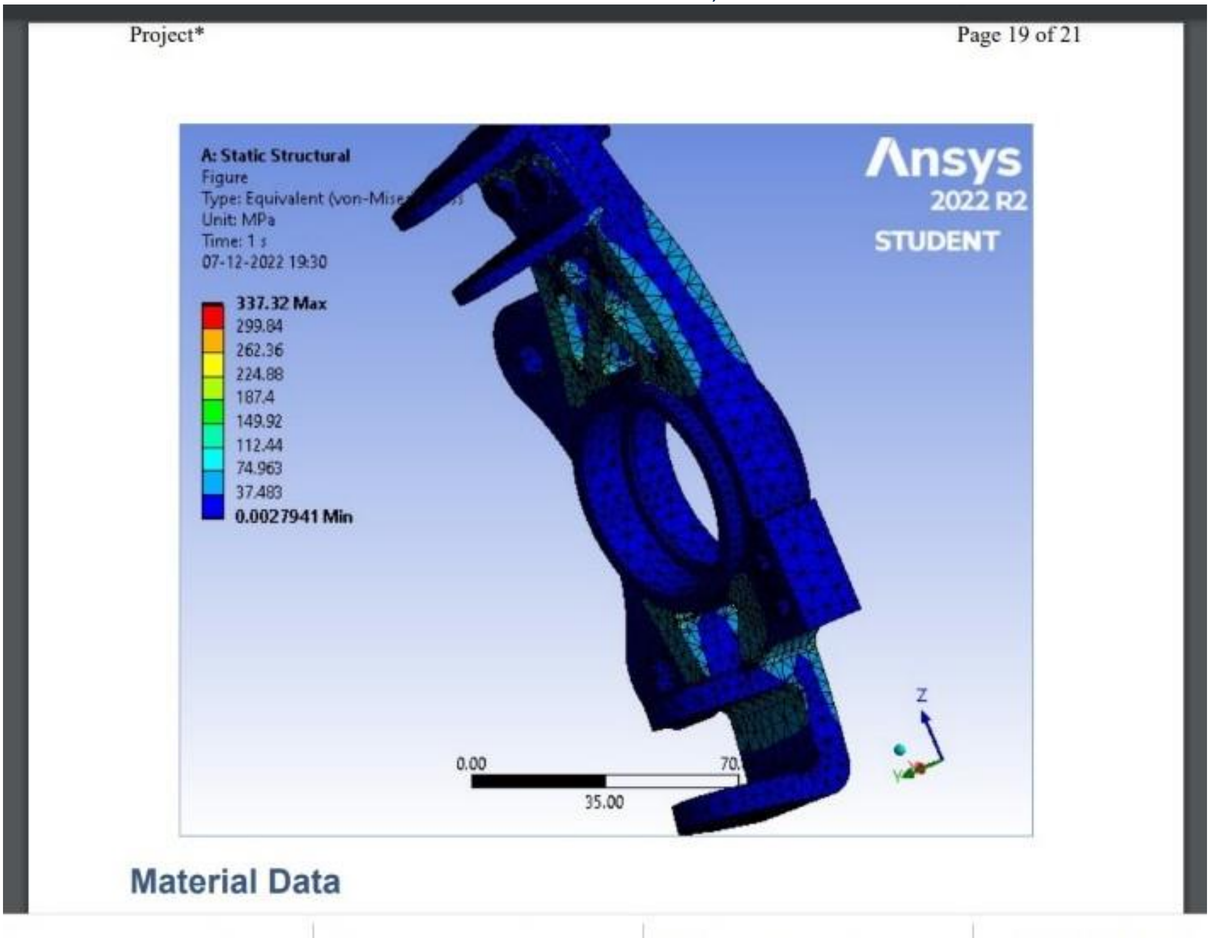


FIGURE 5
Model (A4) > Static Structural (A5) > Solution (A6) > Equivalent Stress



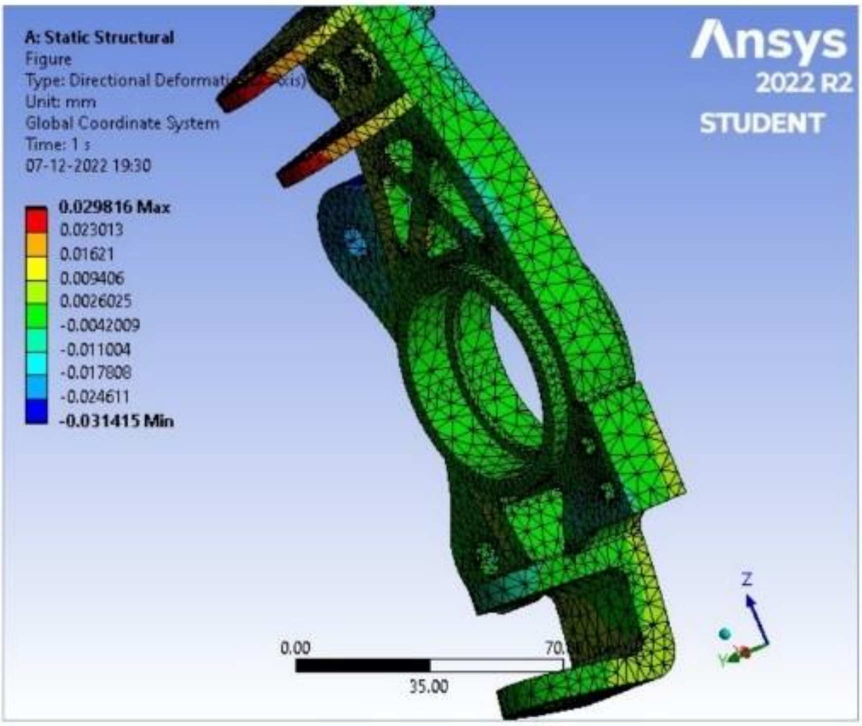


FIGURE 9
Model (A4) > Static Structural (A5) > Solution (A6) > Equivalent Stress

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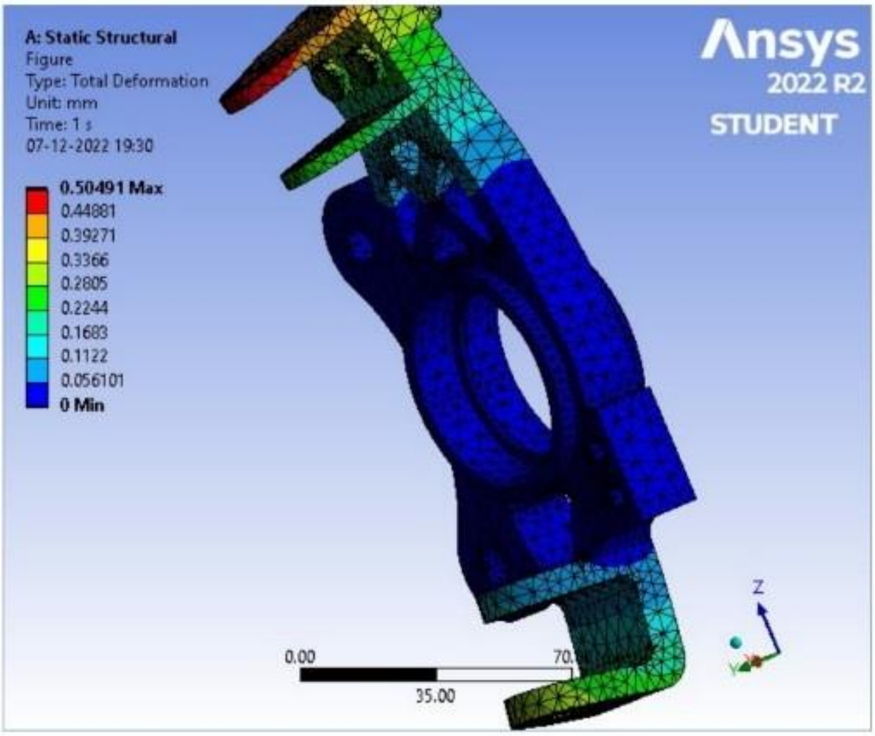
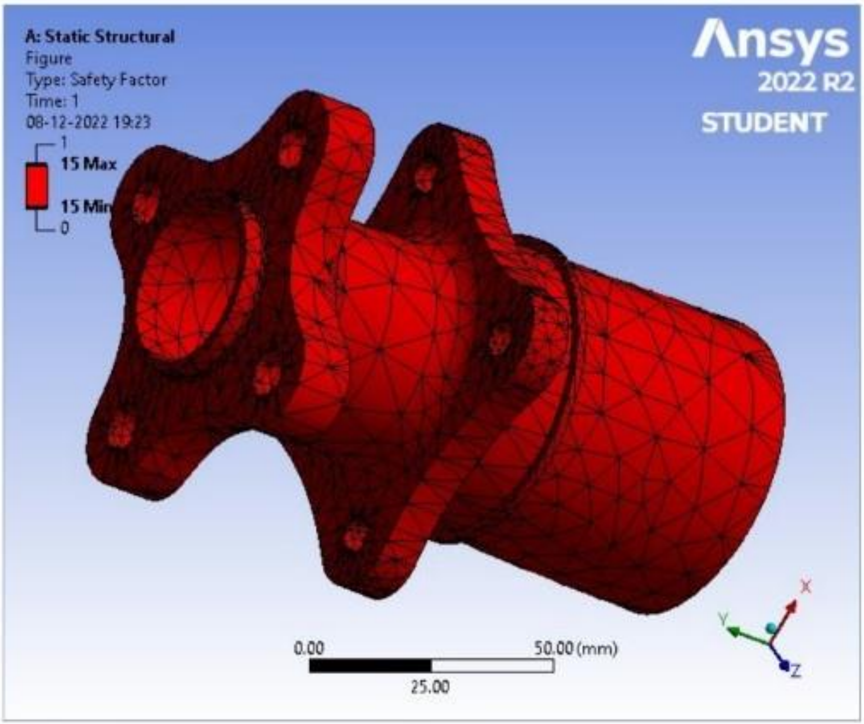


FIGURE 7
Model (A4) > Static Structural (A5) > Solution (A6) > Directional Deformation



Material Data

Project*

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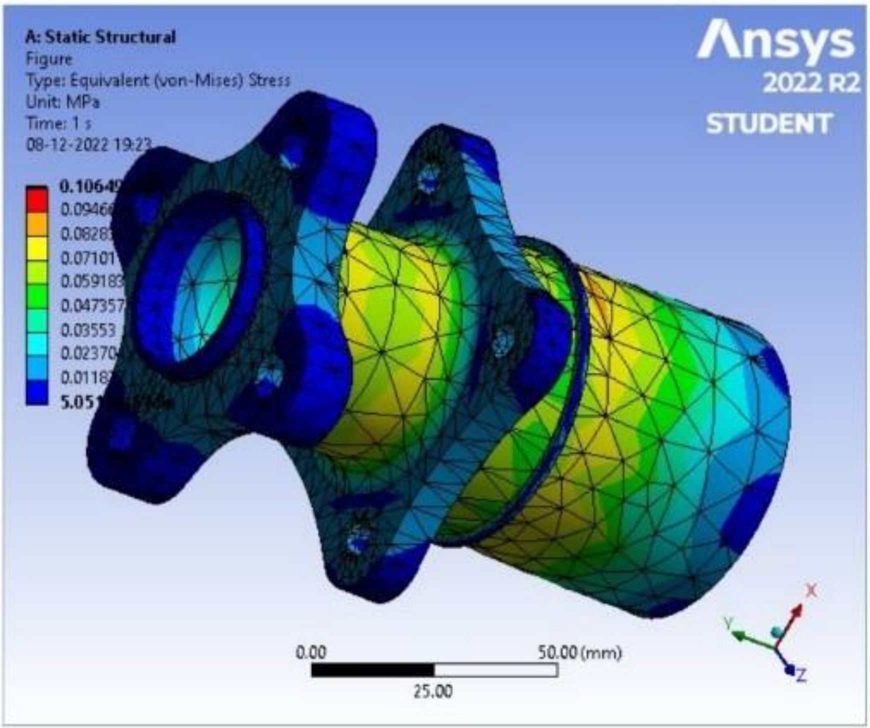

TABLE 17
Model (A4) > Static Structural (A5) > Solution (A6) > Stress Safety Tools

Project*

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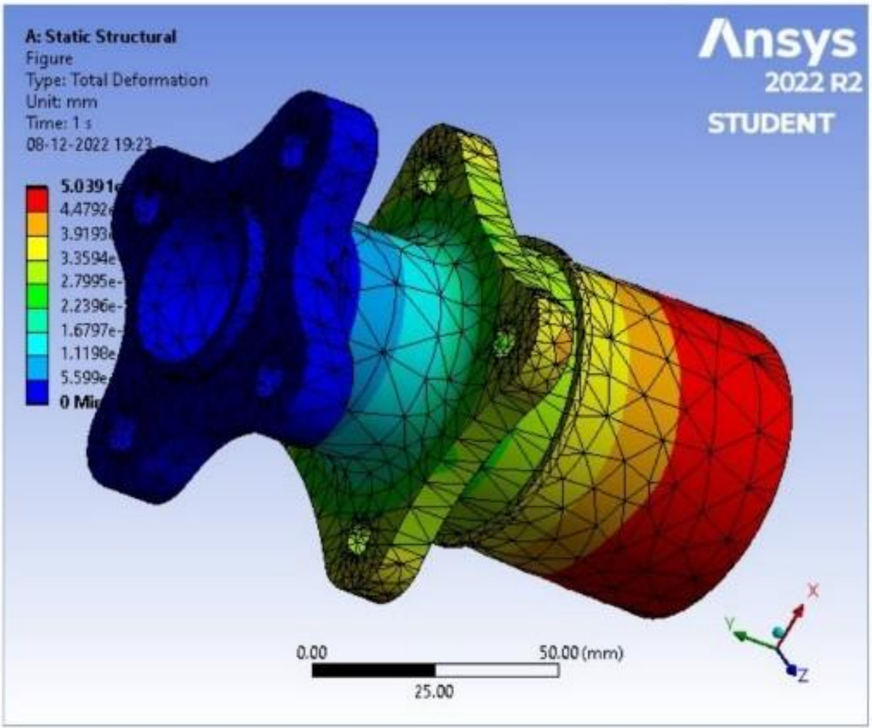
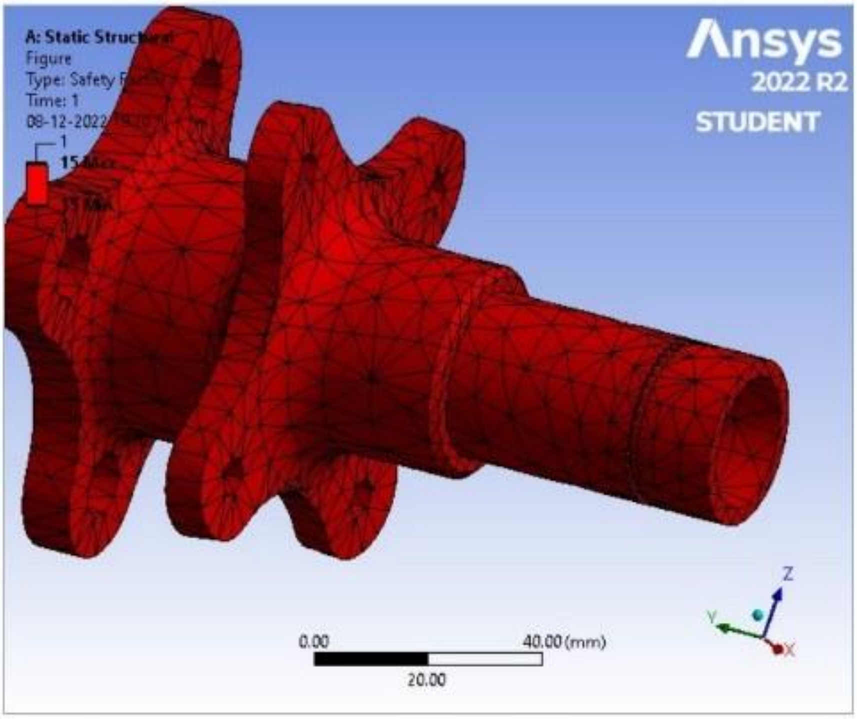


FIGURE 5

Model (A4) > Static Structural (A5) > Solution (A6) > Equivalent Stress



Material Data

Structural Steel

TABLE 20

Project*

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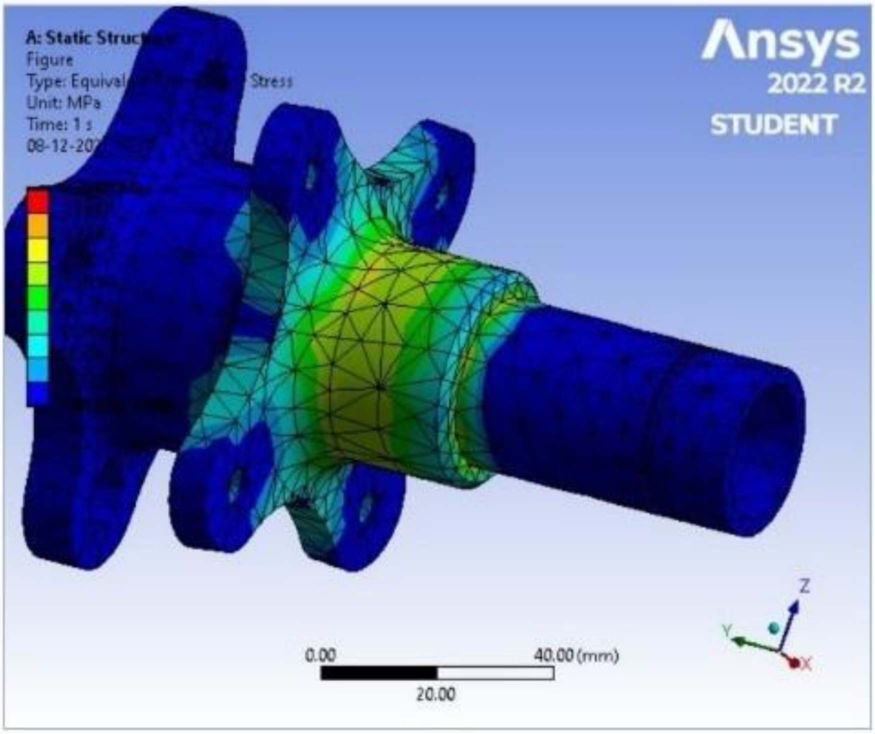


TABLE 17
Model (A4) > Static Structural (A5) > Solution (A6) > Stress Safety Tools

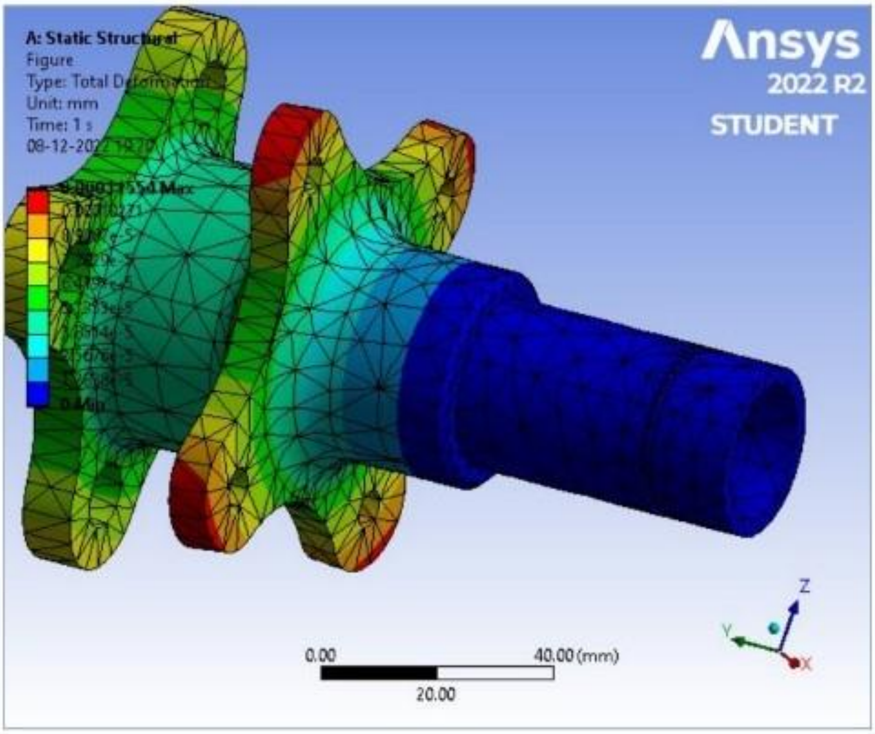
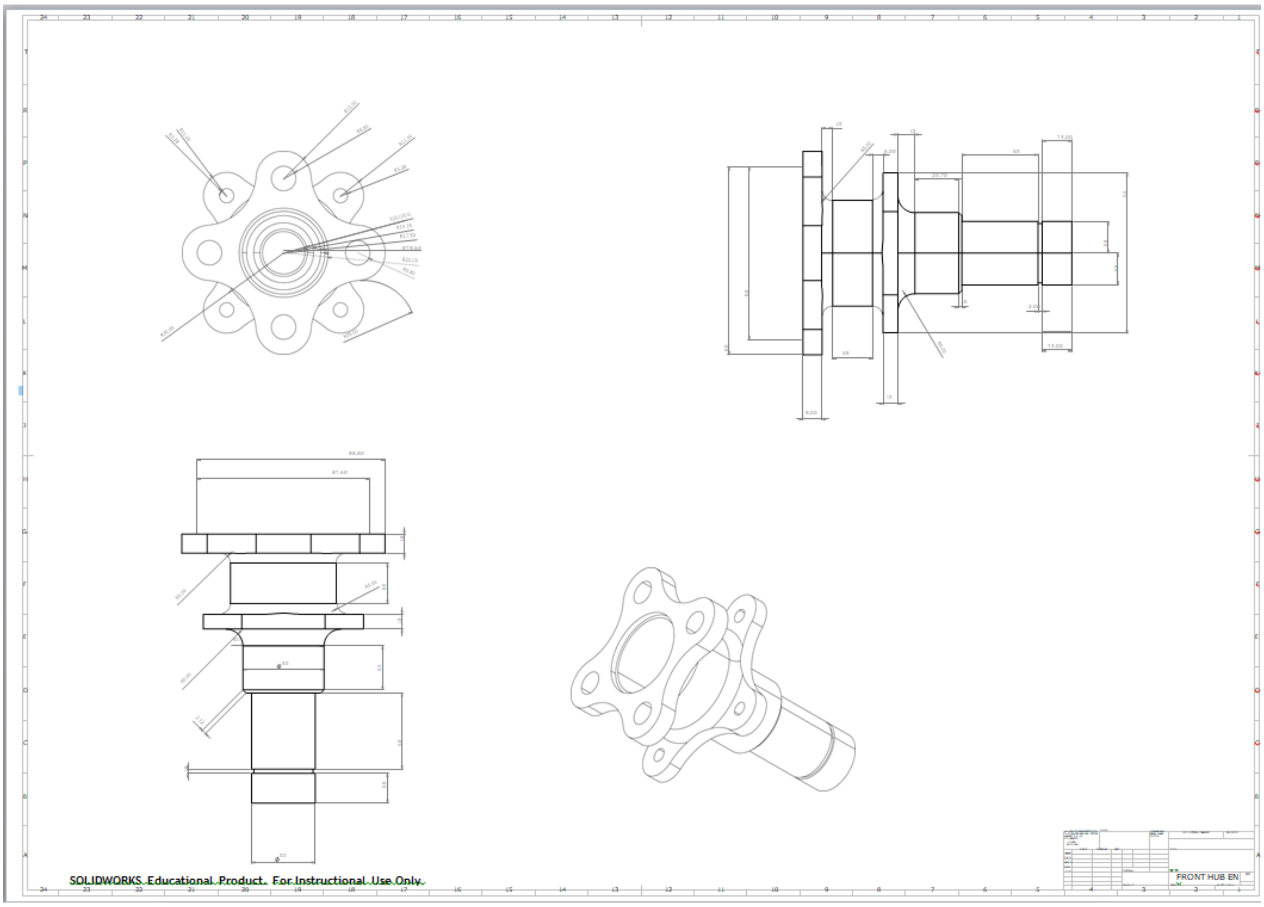
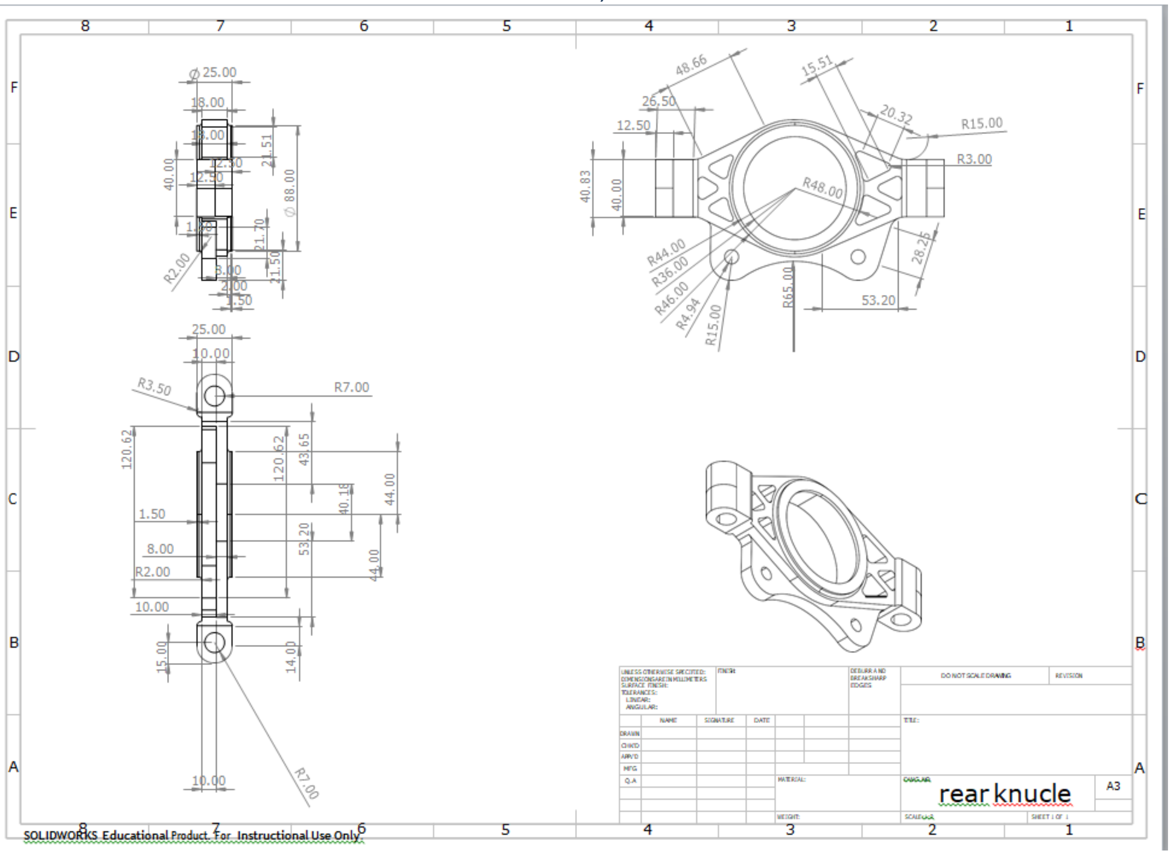


FIGURE 6
Model (A4) > Static Structural (A5) > Solution (A6) > Equivalent Stress

2D Layout



Front hub



Rear Knuckle

THE INTERCEPTORS

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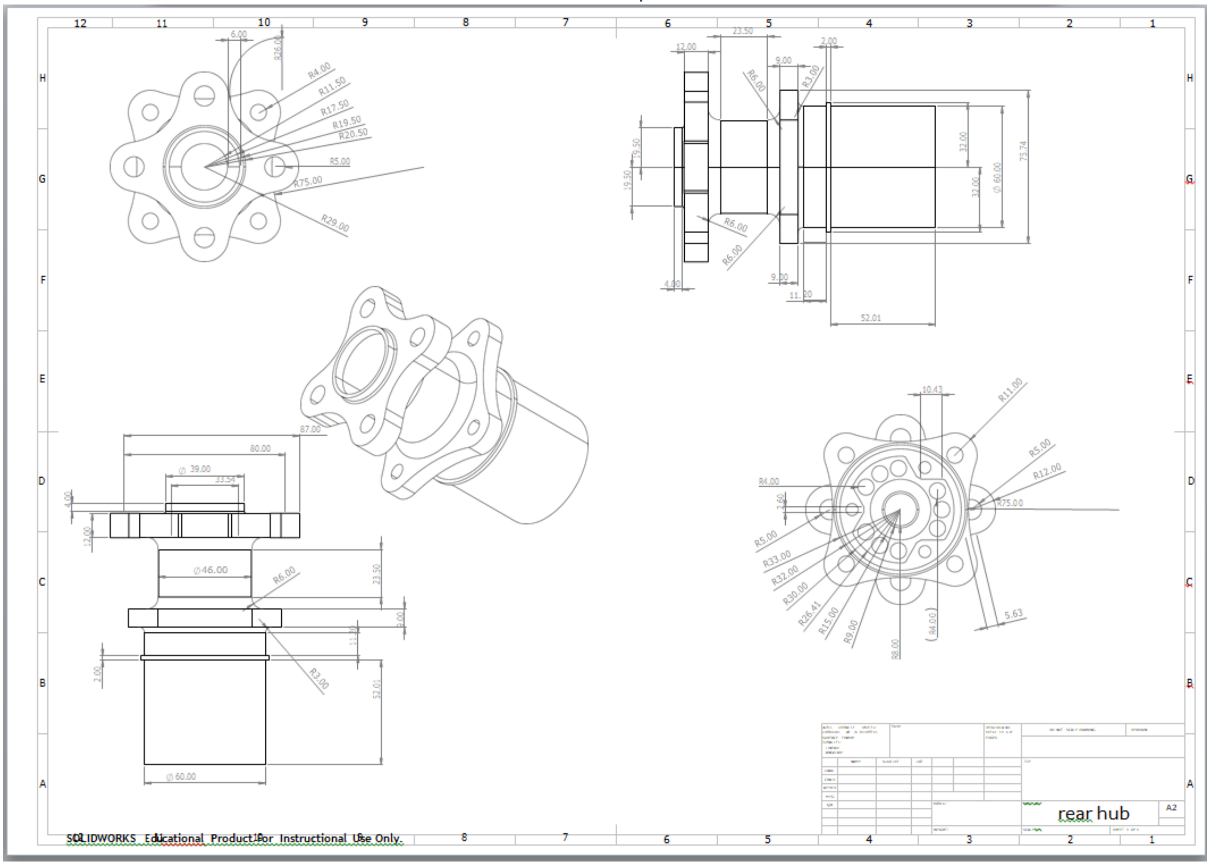
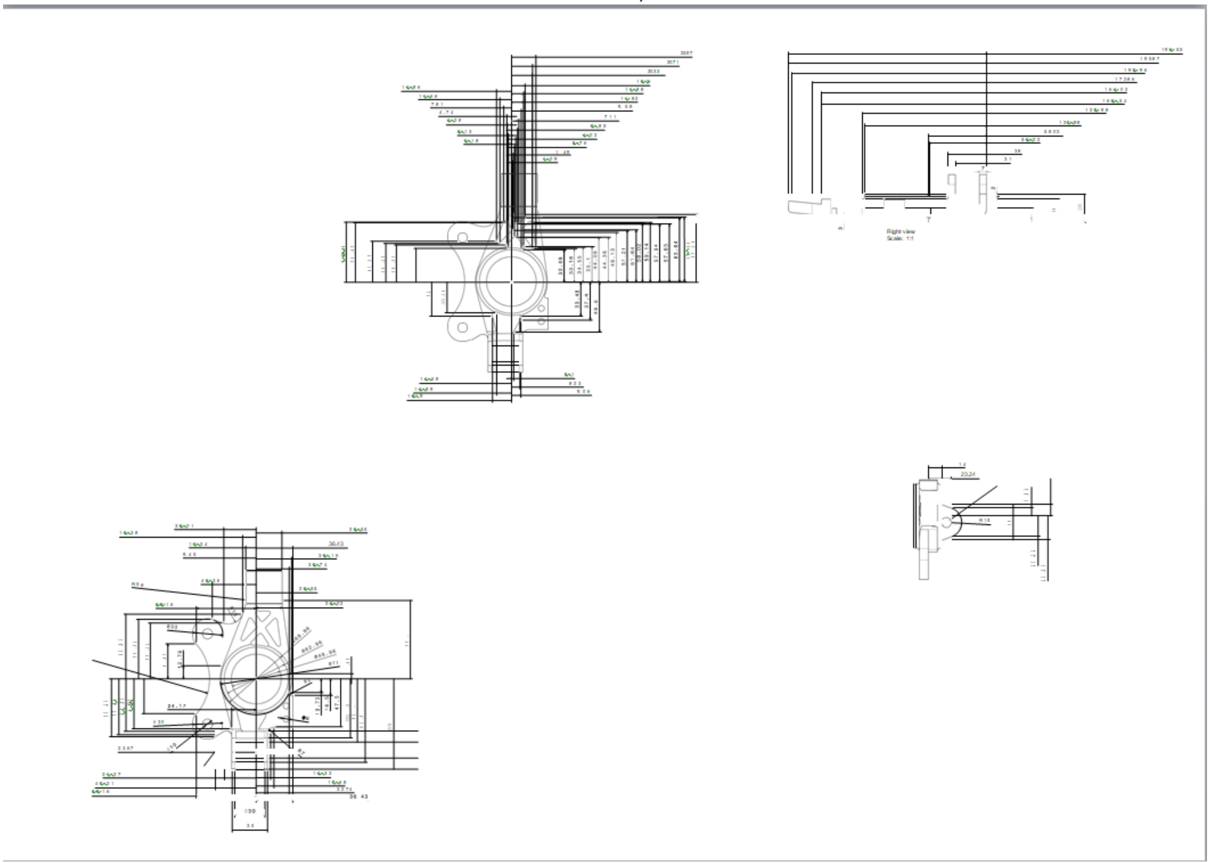


Rear hub



Reference: -

[1] Milliken, W.F., Milliken, D.L. and Metz, L.D., 1995. *Race car vehicle dynamic* (Vol. 400, p. 16). Warrendale: SAE international.

[2] Book, D.D., 2000. PSG college of Technology. *Coimbatore-641*, *4*.

[3]Smith, C., 1978. *Tune to win* (pp. 60-69). Fallbrook: Aero Publishers.