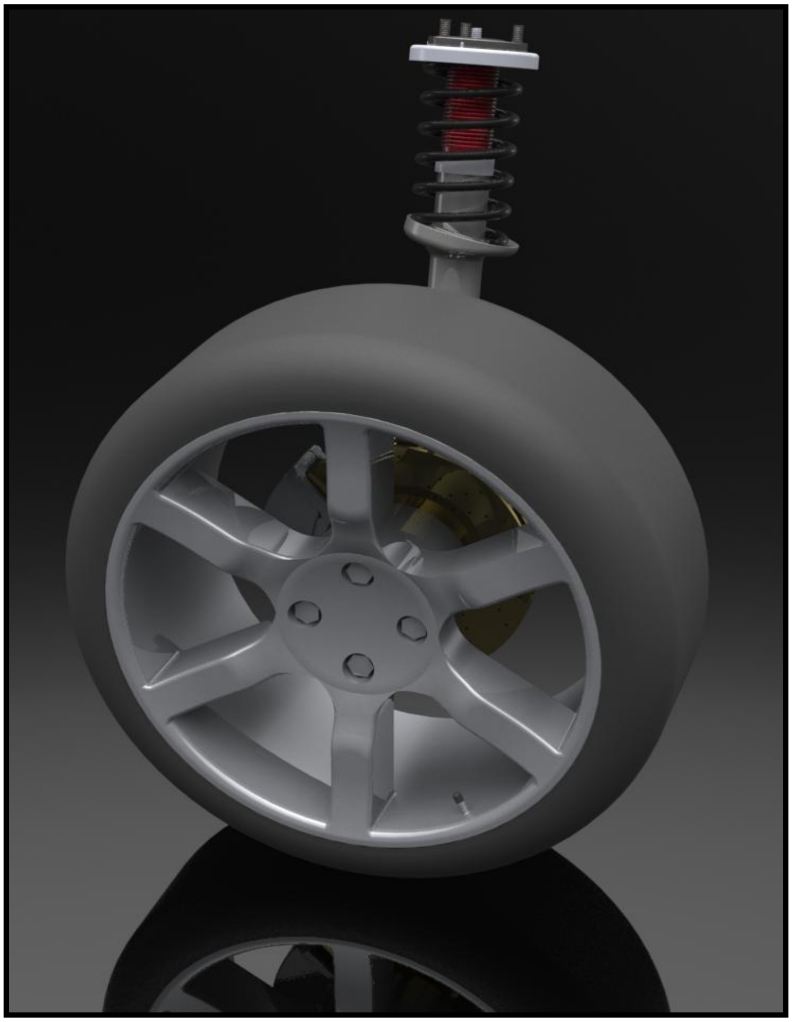
Macpherson Suspension Strut

CAD Solid Modelling



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Abstract

This project was undertaken in order to explore the capabilities of CAD software Solid Edge. For this reason, the dimensions of the suspension system of vehicle Peugeot 307 were taken, which is classified as Macpherson strut wheel suspension.
Components were designed according to these measurements of the suspension system of the chosen vehicle. In addition, the theory was studied to better understand the functionality of the system and to improve the design.

1. Introduction

The main purpose of car suspension system is to support the weight of the vehicle, to maximise the friction between the tires and road surface, and to isolate vibrations from the road (*Hong et al, 1999*). The suspension systems can be classified as active, passive and semi-active (*Joo et al, 2000*). Elements of passive system do not supply energy to the suspension system, and consist of non-controlled spring and shock-absorbing damper (*Sam, 2006*). Active suspension has hydraulic actuator that is parallel with the damper and spring - this system is capable of responding to the changes in the road profile because of its ability to supply energy to produce the relative motion between the wheel and body (*Joo et al, 2000)*.

The most common active suspension system used on smaller vehicles is Macpherson strut (*Gilles, 2005*) – Figure 1. Its popularity is due to its weight, space-saving and cost considerations. Gilles (2005) declares that 'Macpherson strut incorporates the coil spring and shock absorber into its front suspension, using only a single control arm on the bottom'. This allows the whole unit to rotate when steering.

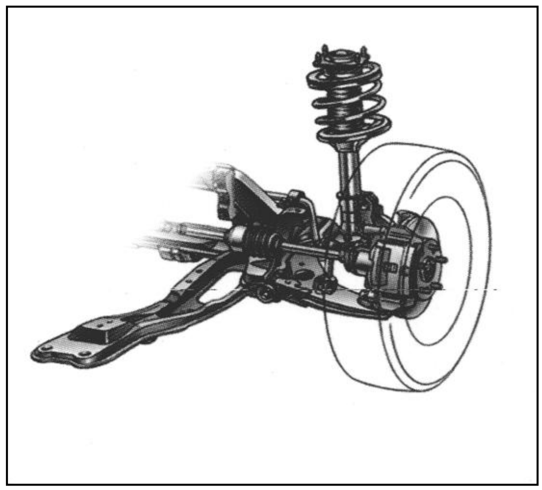

Figure 1: A sketch of the Macpherson strut wheel suspension. *Source: Hong et al, 1999*

The assembly of Macpherson strut suspension system will be demonstrated in this report. This includes subassemblies of: the hub and bearings, wheel and tyre including brake, axle stub and top bearing, and hydraulic cylinder and piston. For modelling, the mechanical design system Solid Edge will be used, which has capabilities of creating and managing 3D digital prototypes (*SolidEdge, 2009*). By using Solid Edge software, the functionality of component can be analysed and changes made to improve the quality of design.

2. Methodology

The beginning stage of the project was to select the motor vehicle that was going to be used to obtain the details of our desired suspension system, retrieve its dimensions and then divide the work between the group members. The chosen vehicle was Peugeot 307, and the dimensions were measured either directly from the car or from the Kingston University automotive lab.

In order to have the accurate model, reduce the number of possible mistakes, and also ensure that all the designed components will go together, the modelling started from an assembly environment from the beginning. All the parts were created associatively within an assembly. Advantage of this method is to save time and have accurate solid model which has large number of components. In addition, if any part needs to be redesigned, other component will follow the update as well as an assembly.

Therefore, the first step was to learn the part modelling associatively within an assembly from beginning and knowing that all the components will be assembled perfectly without losing any time. Modelling started from the alloy wheel, and having the alloy wheel as a base, the developing of the solid model started from there.

The list below shows the step by step modelling of each component by using above method:

- Alloy wheel
- Brake disc
- Calliper and other members of the brake system
- Hub and bearing
- Housing
- Strut and coil spring seat
- Shock absorber tube
- Shock absorber and other components of the shock absorber
- Coil spring
- Spring bumper
- Suspension support and other component

Features that were used to develop the solid model:

Part modelling

1. Extrude
2. Cut extrude
3. Revolve
4. Revolve cut
5. Hole feature
6. Sweep
7. Sweep cut
8. Loft
9. Helix
10. Helix cut
11. Patterns (circular and curve)
12. Fillet and chamfer
13. Mirror

Surface modelling:

1. Bluesurf
2. Extruded surface
3. Swept surface
4. Offset surface

After finishing the whole suspension system, including break system and alloy wheels components, exploded view was used with bill of material to identify each component, and also to show how each component was assembled.

The next step was rendering. Solid Edge software has rendering option itself, however, this does not incorporate high quality and high resolution. Therefore, the Solid Edge model was saved as a Solidworks file. By doing I was able to import each component in to the Photoview 360 for rendering the each part or the assembly of the suspension system.

Finally, the last step was to create engineering 2D drawing from the model (assembly drawing), using the Solid Edge drawing plus bill of material (B.O.M).

3. Alloy wheel

1. Tyre
2. Rim
3. Run flat device
4. Valve and valve cap

Figure 1

Figure 2

Figure 3

Figure 1 shows the tire width, side wall height and the rim diameter which were taken from Peugeot 307: (Appendix 3)

1. Normal width in millimetres
2. Height-to-width ratio, radial construction and rim diameter in inches
3. Load index and speed symbol

Modelling of the rim and tier was based on Figure 1 and was then modified to the 18 inch alloy wheel for the higher performance. Exploded view (Figure 4) shows the number of the components which were modelled for this assembly.

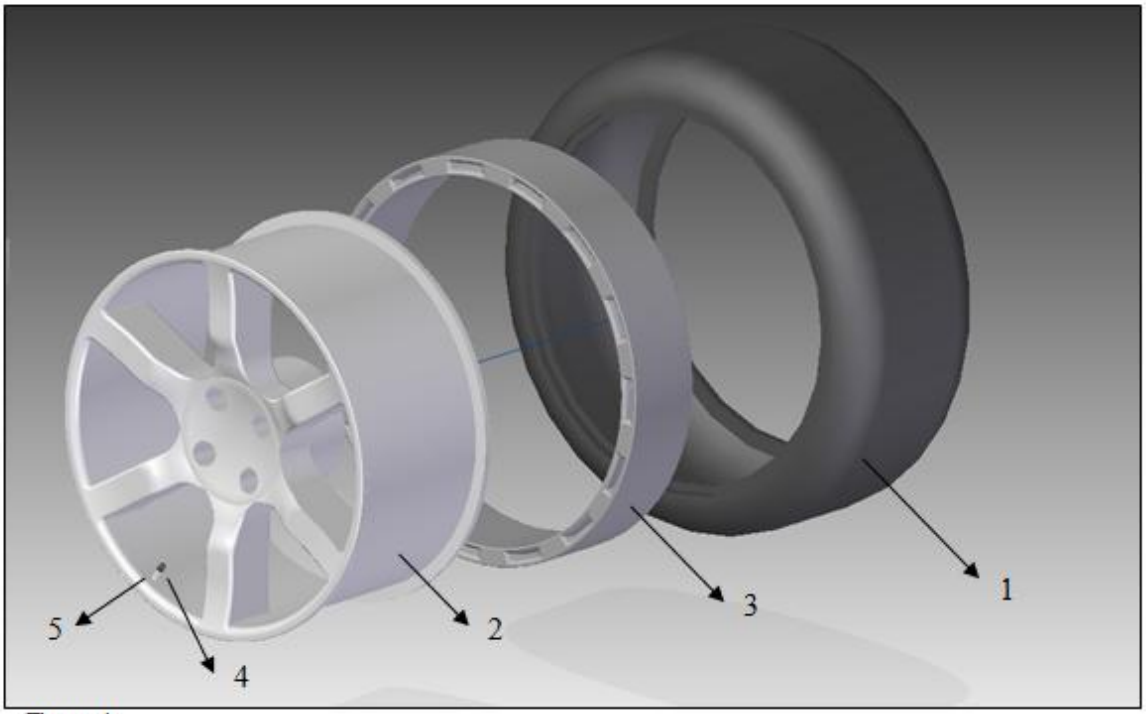

Figure 4

Alloy Wheel B.O.M.		
Item Number	Part Name	QTR
1	Tyre	1
2	Rim	1
3	Run flat device	1
4	Valve	1
5	Valve cap	1

Modelling started from the tire and from there the other components were created by using the method to create part within the assembly. This method was carried out for each individual part to develop the alloy wheel assembly.

4. Brake system and brake disc

1. Calliper
2. Calliper piston
3. Piston seal
4. Pin
5. Piston dust boot
6. Brake shoes
7. Brake pads
8. Brake disc
9. Spring pin bumper

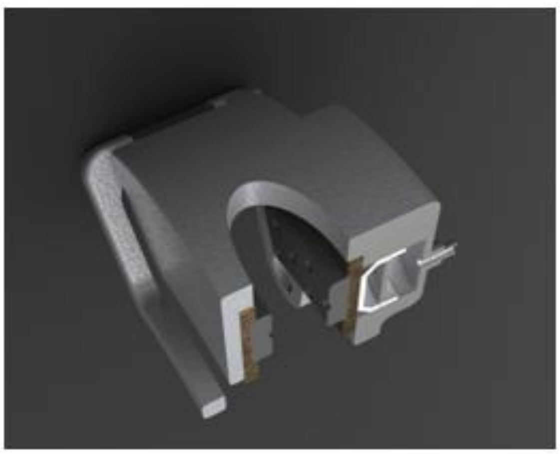

Figure 5

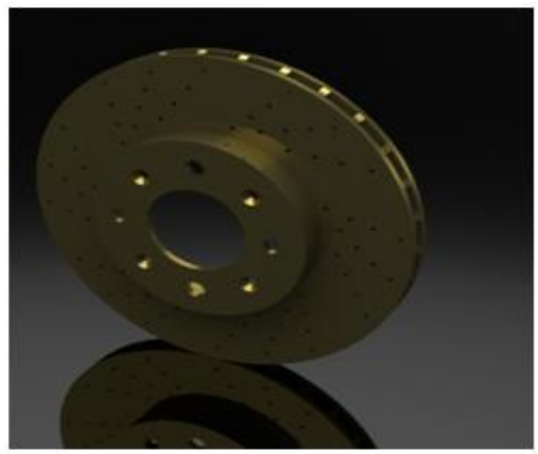

Figure 6

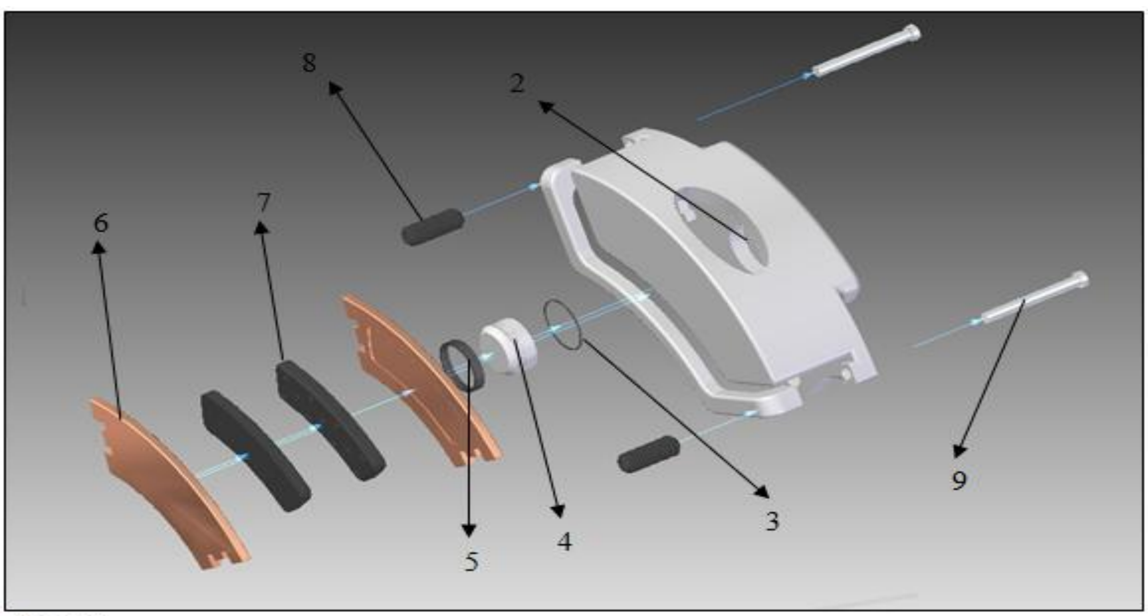

Figure 7

Brake System B.O.M.		
Item Number	Part Name	QTR
1	Calliper	1
2	Cylinder	1
3	Piston seal	1
4	Piston	1
5	Dust boot	1
6	Brake shoe	2
7	Brake pad	2
8	Spring pin bumper	2
9	pin	2

Car brake system is lot like the brakes on a bicycle. Brakes on a bicycle have calliper, which squeezes the brake pads against the wheel. In a car brake system, the brake pads squeeze the rotor instead of the wheel, and the force is transmitted hydraulically instead through the cable (*How Stuff Works, 2009*].

Friction between the pads and the disc slows the disc down. A moving car has a certain amount of kinetic energy, and the brakes have to remove the energy from the car in order to stop it. Each time the car stops, brakes convert the kinetic energy to heat generated by the fraction between the pads and the disc. For the better brake system performance, self-adjusting brakes and high performers brake disc been design for our solid model.

Brake disc model (Figure 6) is vented with material of ceramic. Vented disc has a set of vanes between the two sides of the disc, which pump the air through the disc to provide cooling, also the ceramic material of the brake disc helps to keep the heat low.

Single piston floating calliper disc brake is self-centring and self-adjusting, which has been the model for the brake system (Figure 5), the calliper is able to slide from side to side, so it will move to the centre each time the brakes are applied. Also, since there is no spring to pull the pads away from the disc, the pads always stay in light contact with the rotor (the rubber piston seal and any wobble in the rotor may actually pull the pads a small distance away from the rotor).

This is important because the pistons in the brakes are much larger in diameter then the ones in the master cylinder. If the brake piston retracted into their cylinder, it might take several application of the brake pedal to pump enough fluid into the brake cylinder to engage the brake pads.

Disc brake diagram

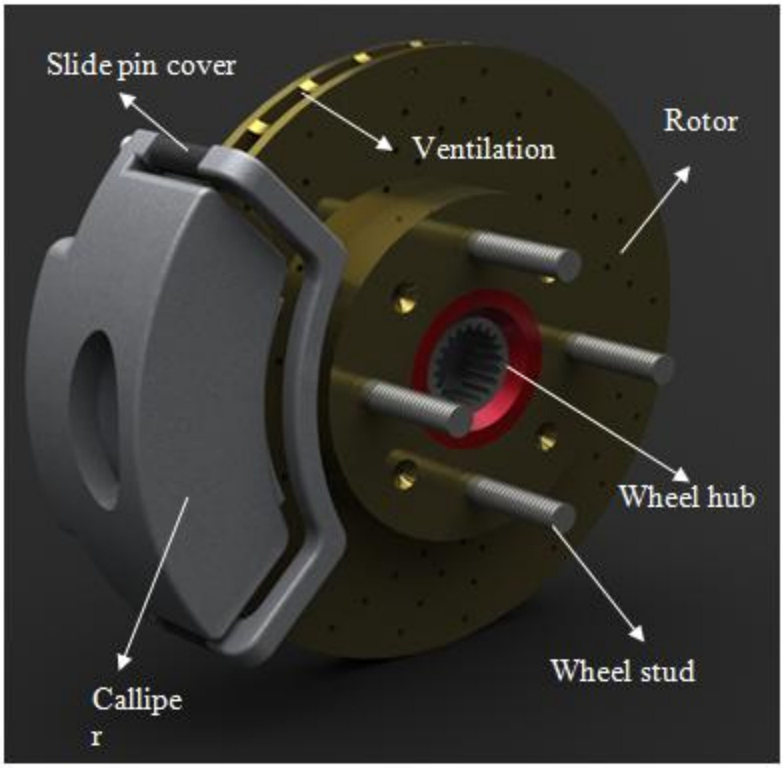

Figure 8

5. Hub and bearing assembly

1. Hub
2. Retainer and balls
3. Inner racer
4. Outer racer
5. Inner shield
6. Outer shield

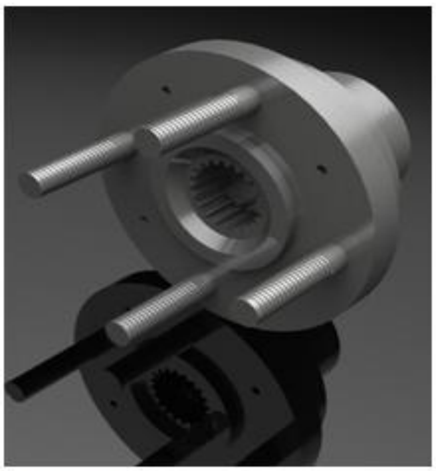

Figure 9

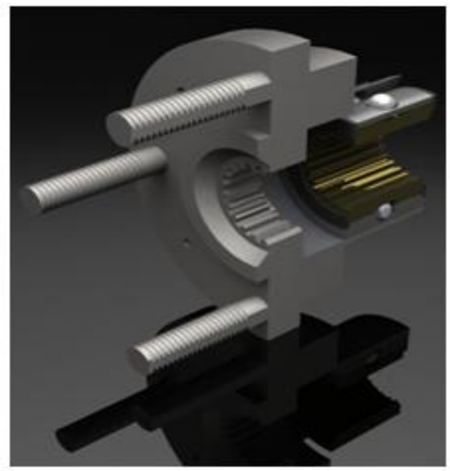

Figure 10

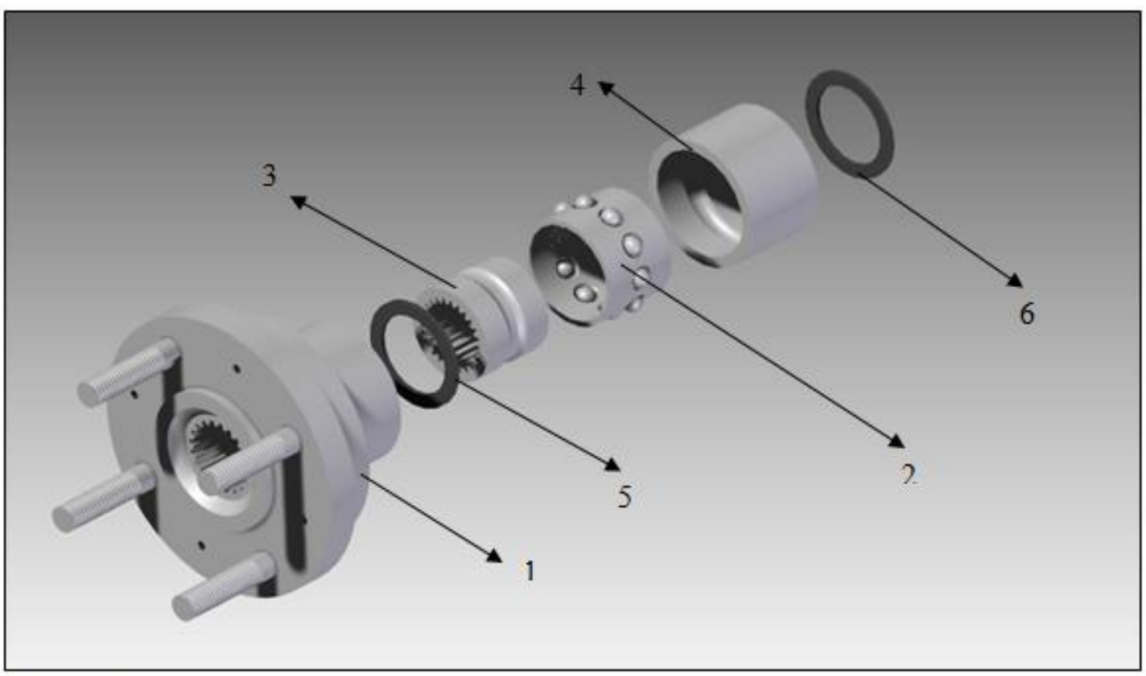

Figure 11

Hub B.O.M.		
Item Number	Part Name	QTR
1	Hub	1
2	Retainer and ball	1
3	Inner racer	1
4	Outer racer	1
5	Inner shield	1
6	Outer shield	1

6. Steering knuckle and Strut

1. Steering knuckle
2. Strut

Figure 12

Figure 13

7. Shock absorber

Figure 14

Figure 15

A shock absorber is basically an oil or air pump placed between the frame of the car and wheel. When the car wheel encounters a bump in the road and causes the spring to coil and uncoil, the energy of the spring is transferred to the shock absorber through the upper mount, down through the piston rod and into the piston, orifices perforate the piston and allow fluid to leak through as the piston moves up and down in the pressure tube. Because the orifices are relatively tiny, only a small amount of fluid, under great pressure passes through. This slows down the piston which in return slows down the spring.

Shock absorber works in two cycles (compression cycle and extension cycle). The compression cycle occurs as the piston moves downwards, compressing the hydraulic fluid in the chamber below the piston. The extension cycle occurs as the piston moves toward the top of the pressure tube. The compression cycle control the motion of the vehicle's unsprung weight, while extension controls the heavier sprung weight.

All modern shock absorbers are velocity sensitive - the faster the suspension moves, the more resistance the shock absorber provides (*Gilles, 2005*). This enable shocks to adjust to road conditions and to control all of the unwanted motion that can occur in a moving vehicle, including bounce, sway, brake, dive and acceleration squat.

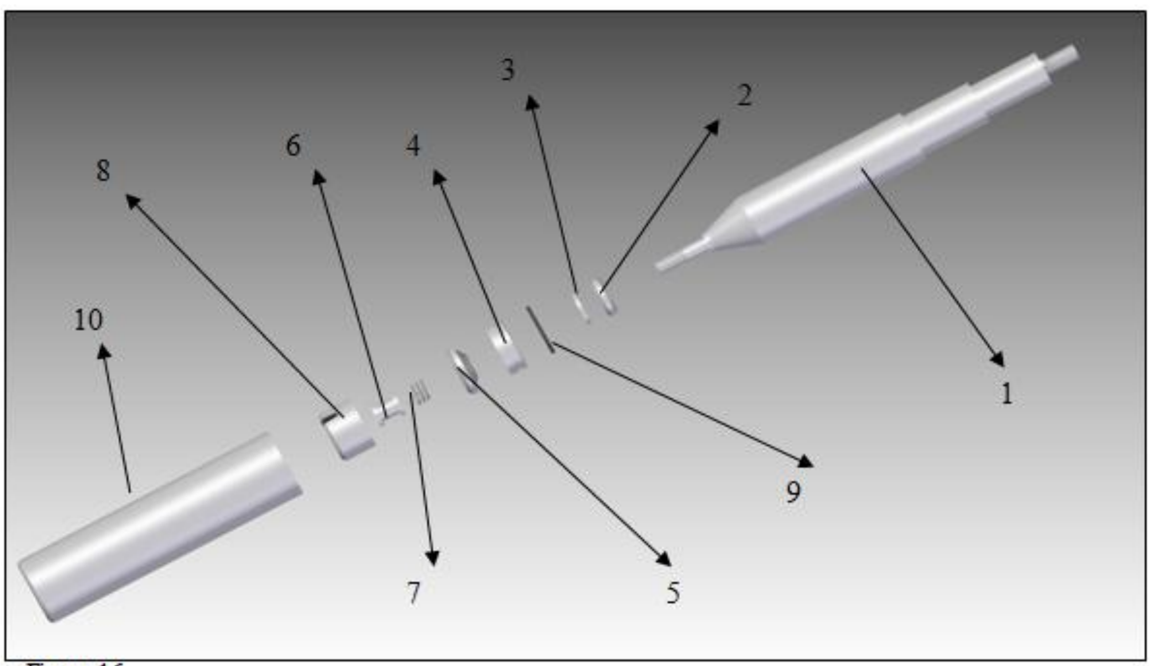

Figure 16

Shock absorber B.O.M		
Item Number	Part Name	QTR
1	Piston rod	1
2	Top out	1
3	Rebound	1
4	Shock absorber piston	1
5	Valve disk	1
6	Shock absorber nut	1
7	Shock absorber spring	1
8	Shock absorber bottom valve	1
9	O Ring	1
10	Tube	1

8. Assembly of the suspension system and strut

1. Strut
2. Shock absorber assembly
3. Bush
4. Closure plate
5. Rod
6. Spring bumper
7. Coil spring
8. Upper cover coil spring
9. Lid
10. Ring lid
11. Suspension support

Figure 17

Figure 18

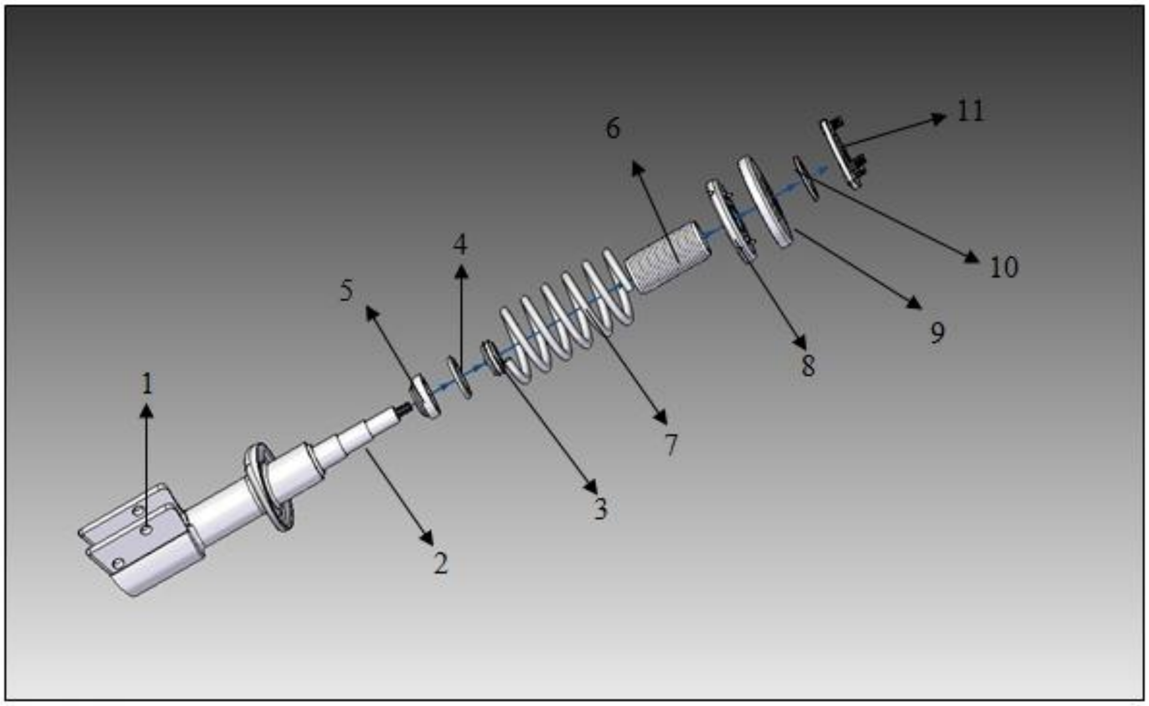

Figure 19

Suspension system B.O.M.		
Item Number	Part Name	QTR
1	Strut	1
2	Shock absorber	1
3	Bush	1
4	Closure plate	1
5	Rod	1
6	Spring bumper	1
7	Coil spring	1
8	Upper cover coil spring	1
9	Lid	1
10	O ring	
11	Suspension support	1

9. Complete assembly of the front suspension system and alloy wheel

The structure of the model been divided from the main assembly to three subassemblies. The main assembly contains alloy wheel assembly, brake system assembly and the suspension system assembly.

The next step after modelling was to have exploded view of each subassembly and bill of material to indicate the parts how to go together, by saving the each subassembly with exploded configuration then we were able to have the views in the drawing.

Once the all above stages been complete by using solid edge software then model been transform to solidworks file for rendering of the component using the photoview 360 package.

Figure 20

10. Conclusion

As we can clearly observe computers today are rapidly declining in cost at same rate in which computer power in increasing to level of unbelievable precision, which as therefore increased the further development in solid edge which can now produce precise and accurate engineering components.

Solid edge is basically a model that has been produced on computer that has been subjected to different forms of testing for analysed results. Companies can therefore use this package for new product design or modification, in which they are able to tell whether or not the product will perform or fail to specification. Whether or not this new or modified product fails to meet the specification after testing we can deploy solid edge to determine the areas of modification to meet specification.

Using a 3D CAD drawing platform the designer is able to develop 3D models and components using the design tools on the computer. This is an obvious advantage to the use of drawing boards as we do not need for example new drawings when editing for modification.

Being able to reduce recurring tasks is one of the great advantages behind this piece of software. Modifying designs to reach their maximum potential is the application which is cutting down man hours in favour of increasing the efforts of computers. These methods are able to produce solutions efficiently compared to the methods adopted by humans. This is because the mathematics that is embedded into these systems is more efficient to that of humans. However, these systems do not replace the understanding of humans; we are of course the creators and our intuition can allow us at times to shorten the design cycle.

Another advantage of this software over manual methods is that solid edge type applications are put into practice properly, should take into account all feasible options and possibilities. Consider all design parameters which therefore means that the design created using the software should be accurate to the specification to determine correct solutions.

As our work is produced on computer the work can be easily stored (saved) for future viewing and if needed be the work produced could also be duplicated much efficiently and accurately.

Disadvantage to new pieces of software is that firstly computer network are expensive to set up. Also new technology is always coming out and changing which therefore means that in order to keep up if competition you will need to train up your employees which takes time and effort which therefore costs money.

11. References

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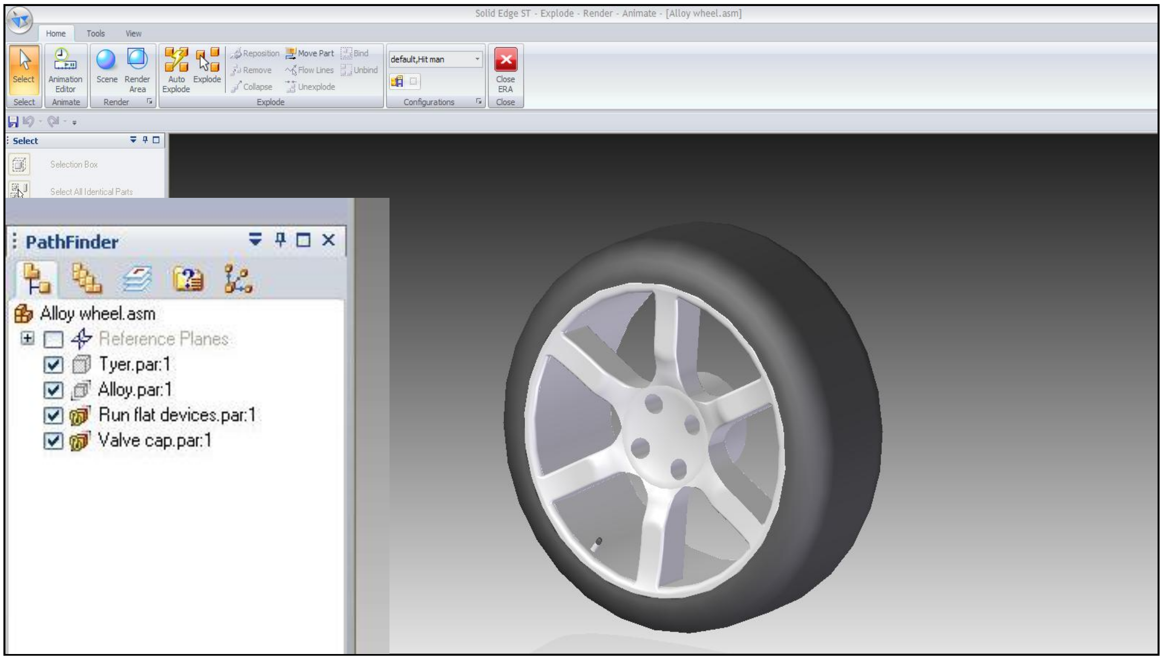
Appendix 1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Tools
View
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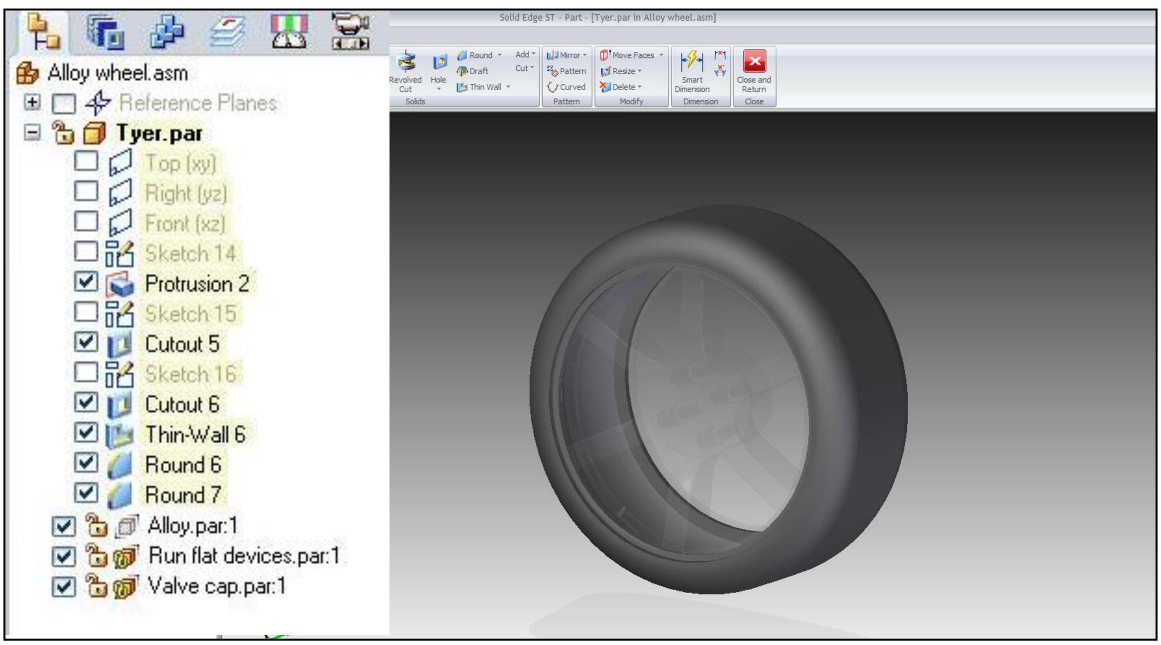
PathFinder
Alloy wheel.asm
Reference Planes
Tyer.par:1
Alloy.par:1
Run flat devices.par:1
Valve cap.par:1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Tyer.par
Top (xy)
Right (yz)
Front (xz)
Sketch 14
Protrusion 2
Sketch 15
Cutout 5
Sketch 16
Cutout 6
Thin-Wall 6
Round 6
Round 7
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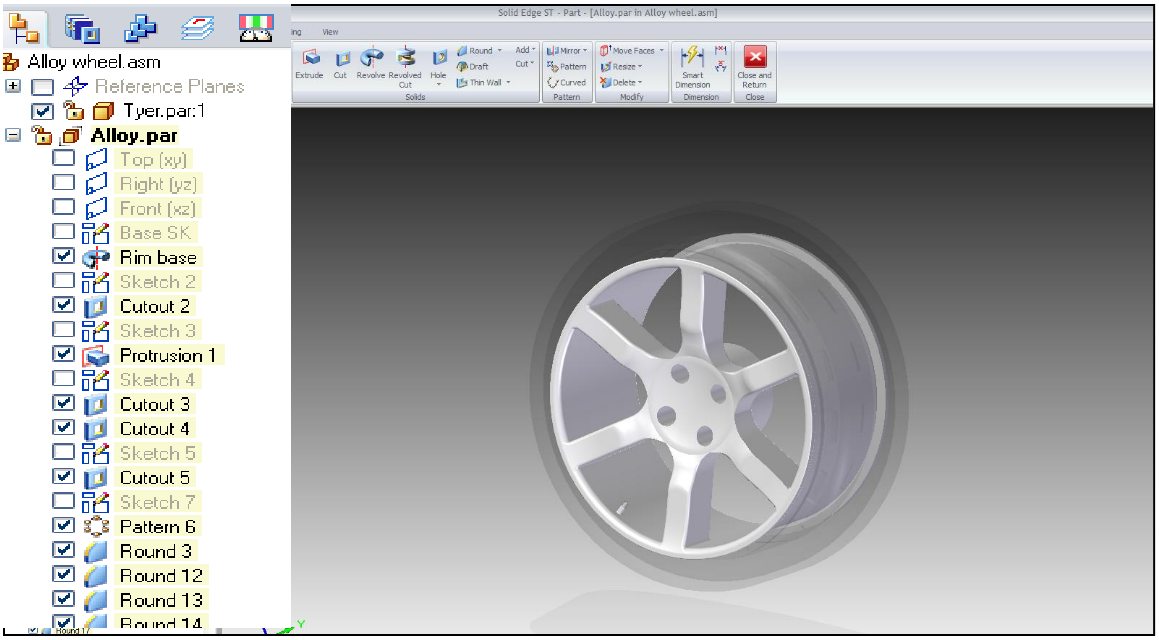
Run flat devices.par:1
Valve cap.par:1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Alloy wheel.asm
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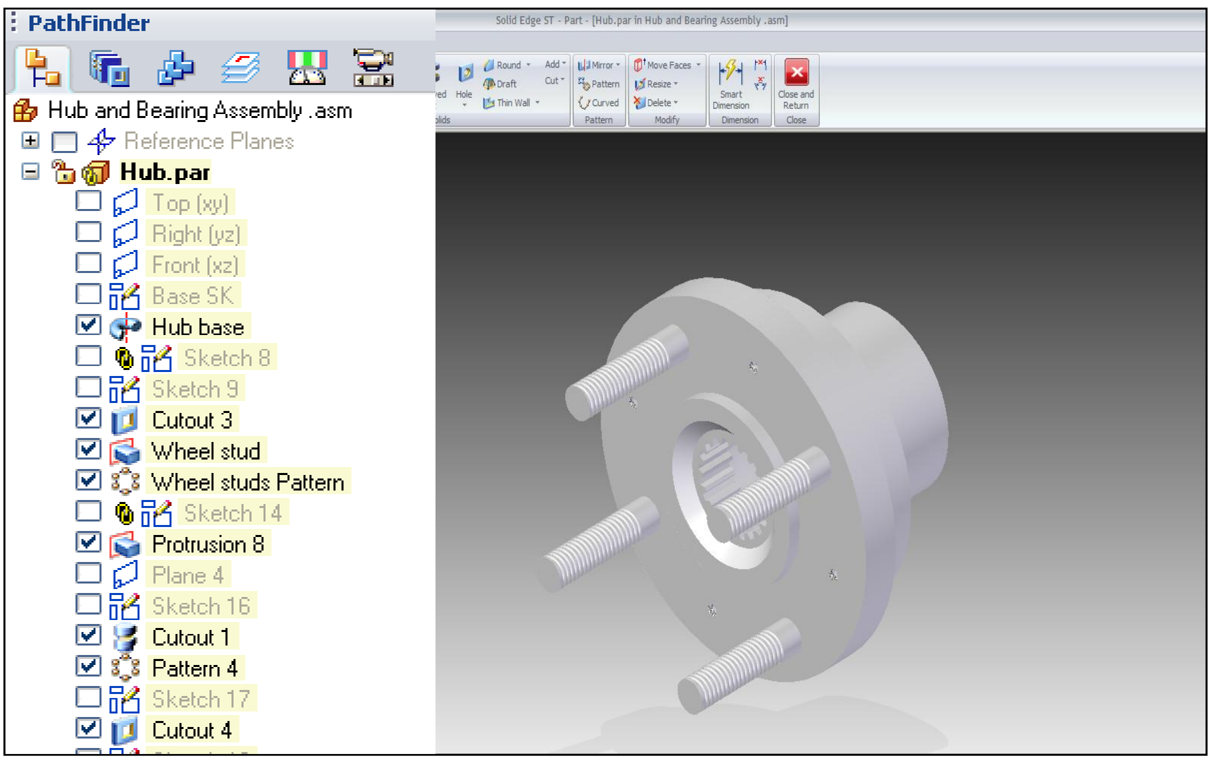
Tyer.par:1
Alloy.par
Top (xy)
Right (yz)
Front (xz)
Base SK
Rim base
Sketch 2
Cutout 2
Sketch 3
Protrusion 1
Sketch 4
Cutout 3
Cutout 4
Sketch 5
Cutout 5
Sketch 7
Pattern 6
Round 3
Round 12
Round 13
Round 14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Hub and Bearing Assembly .asm
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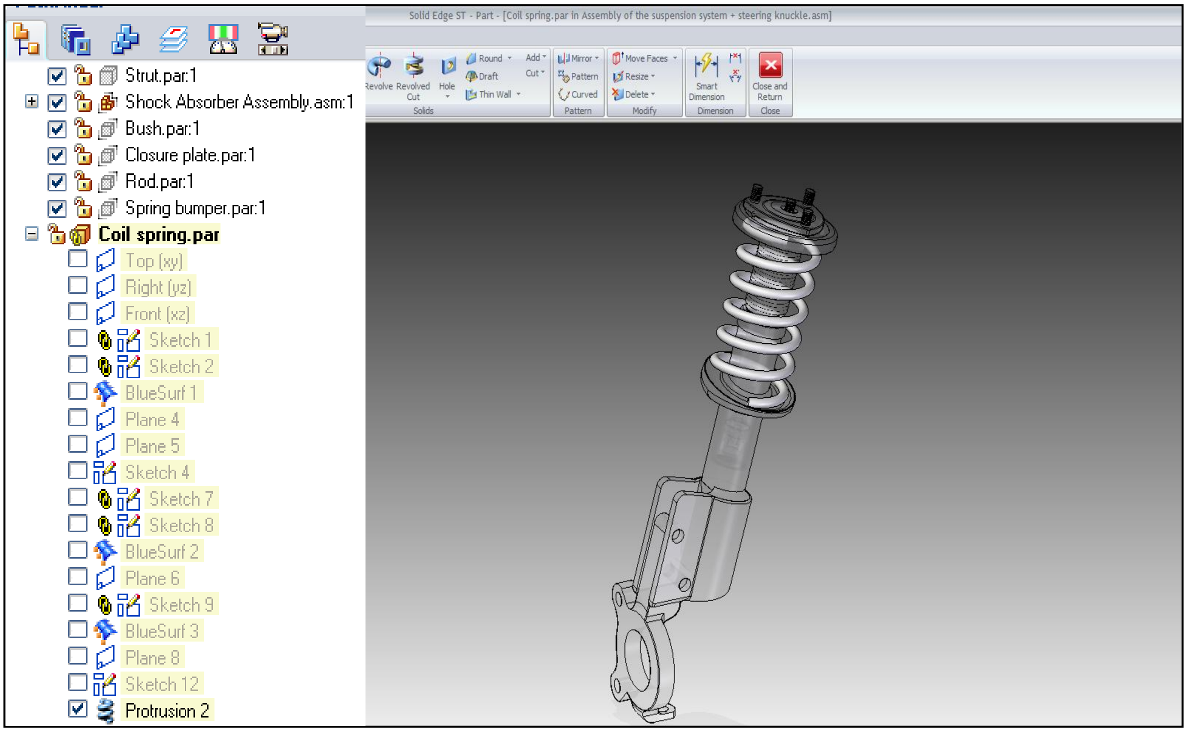
Right (yz)
Front (xz)
Base SK
Hub base
Sketch 8
Sketch 9
Cutout 3
Wheel stud
Wheel studs Pattern
Sketch 14
Protrusion 8
Plane 4
Sketch 16
Cutout 1
Pattern 4
Sketch 17
Cutout 4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Shock Absorber Assembly.asm:1
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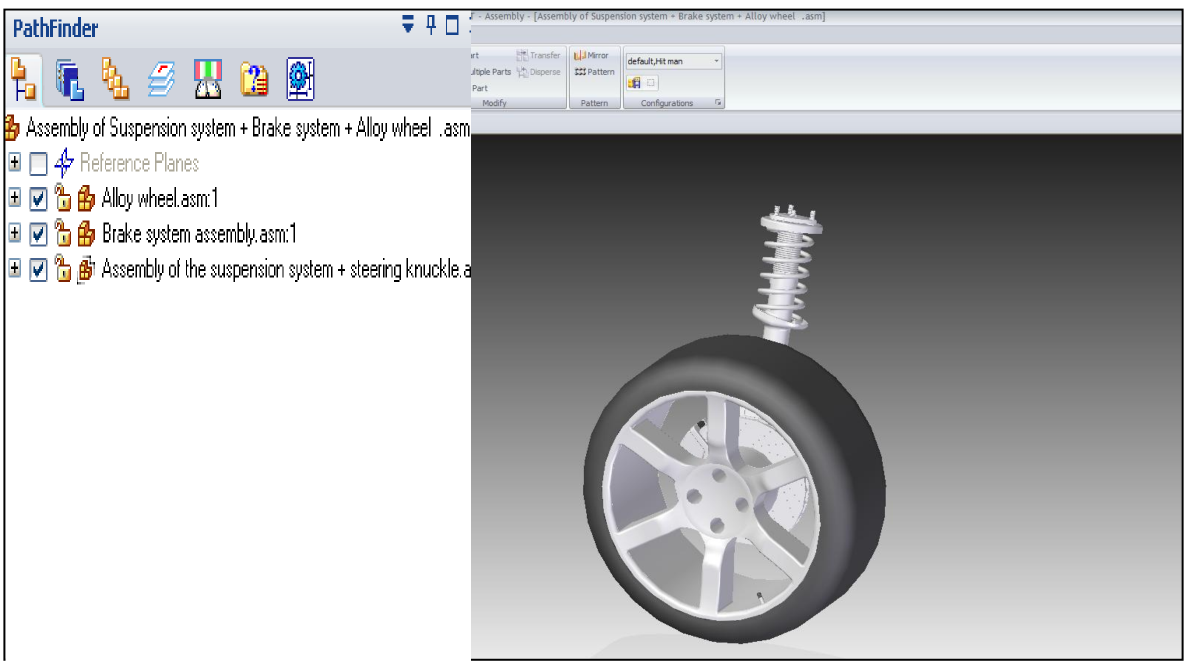
Closure plate.par:1
Rod.par:1
Spring bumper.par:1
Coil spring.par
Top (xy)
Right (yz)
Front (xz)
Sketch 1
Sketch 2
BlueSurf 1
Plane 4
Plane 5
Sketch 4
Sketch 7
Sketch 8
BlueSurf 2
Plane 6
Sketch 9
BlueSurf 3
Plane 8
Sketch 12
Protrusion 2


PathFinder
Assembly of Suspension system + Brake system + Alloy wheel .asm
Reference Planes
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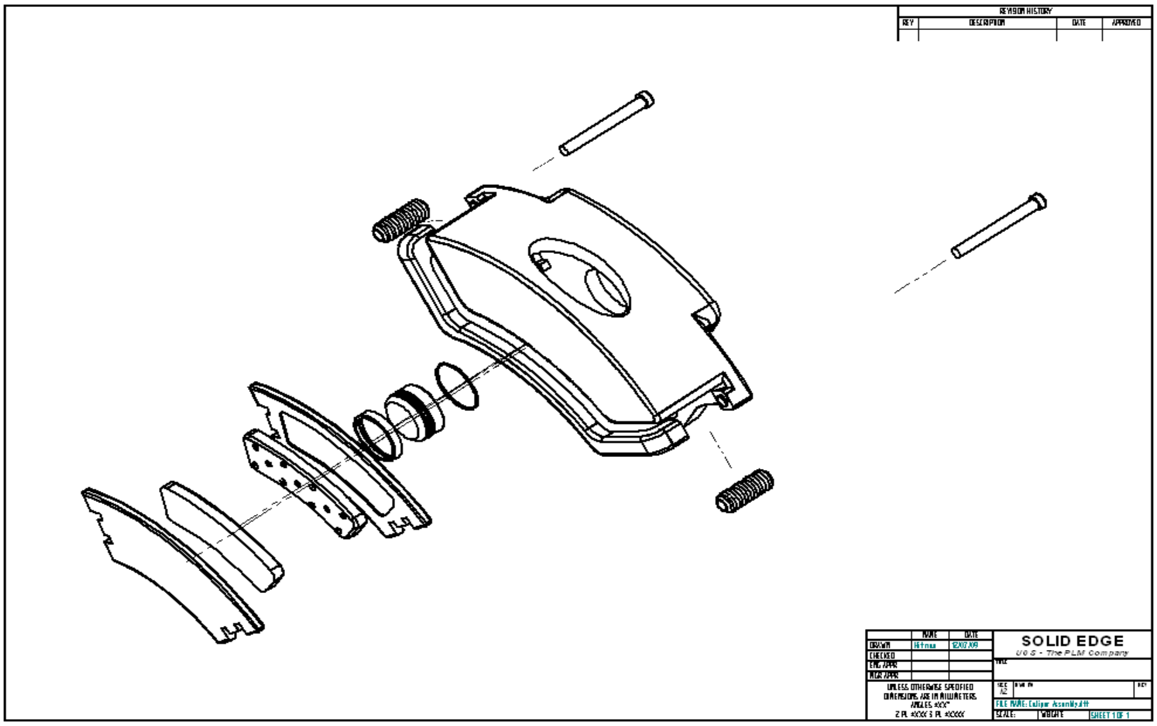
Brake system assembly.asm:1
Assembly of the suspension system + steering knuckle.a

Appendix 2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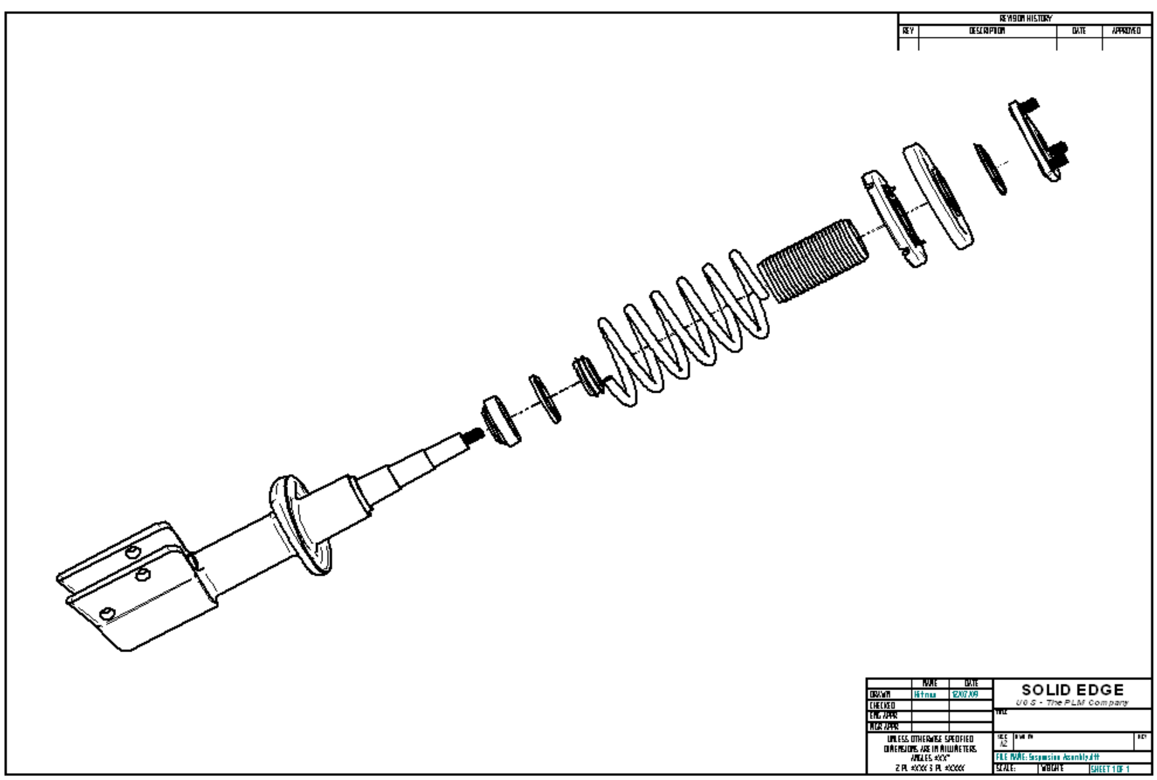
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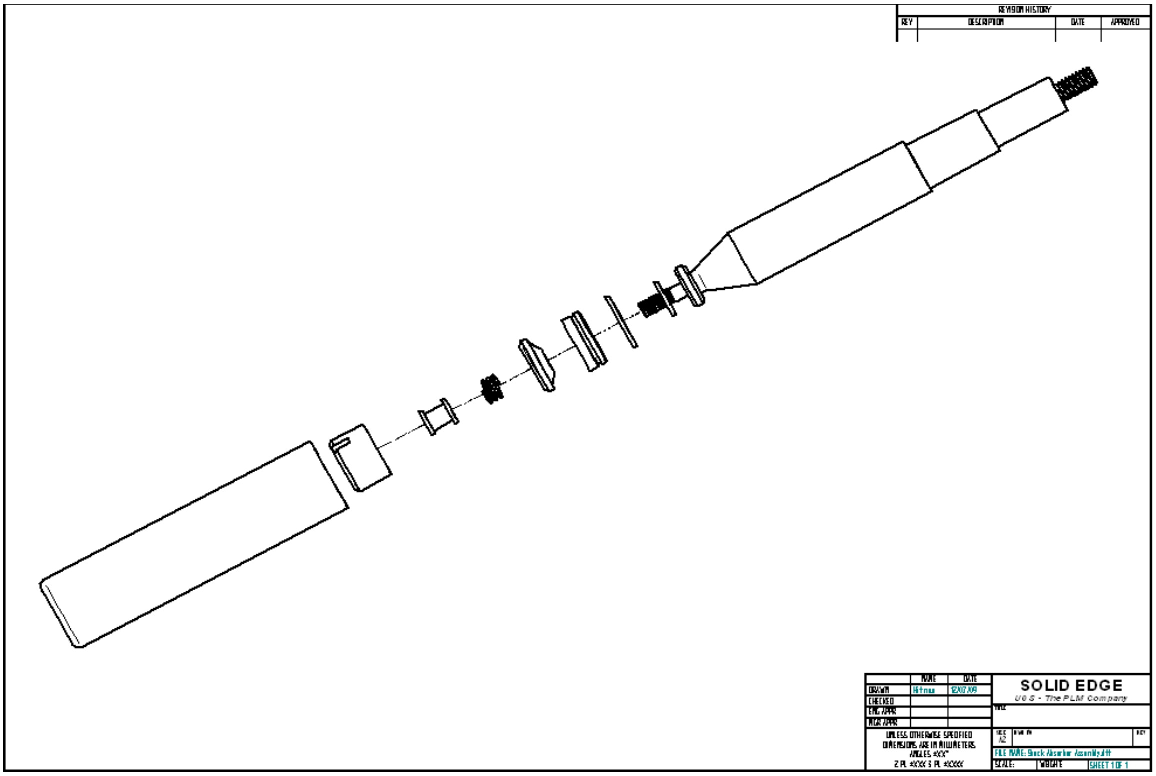
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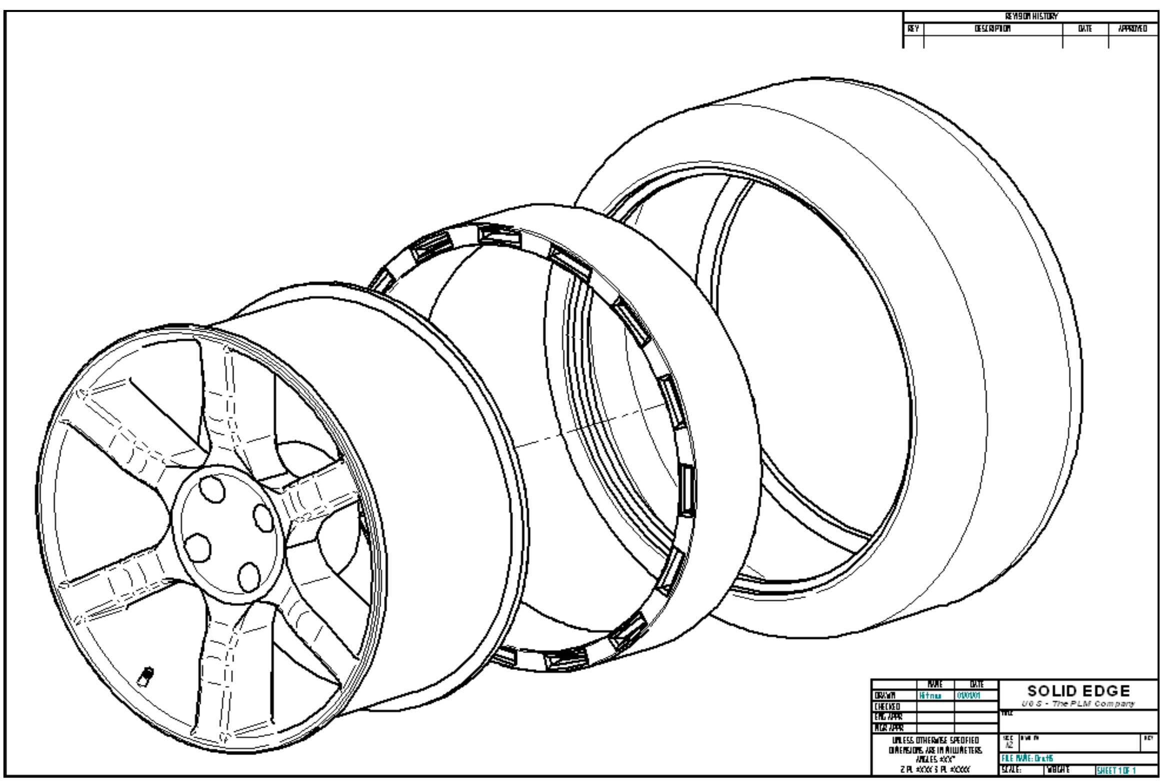
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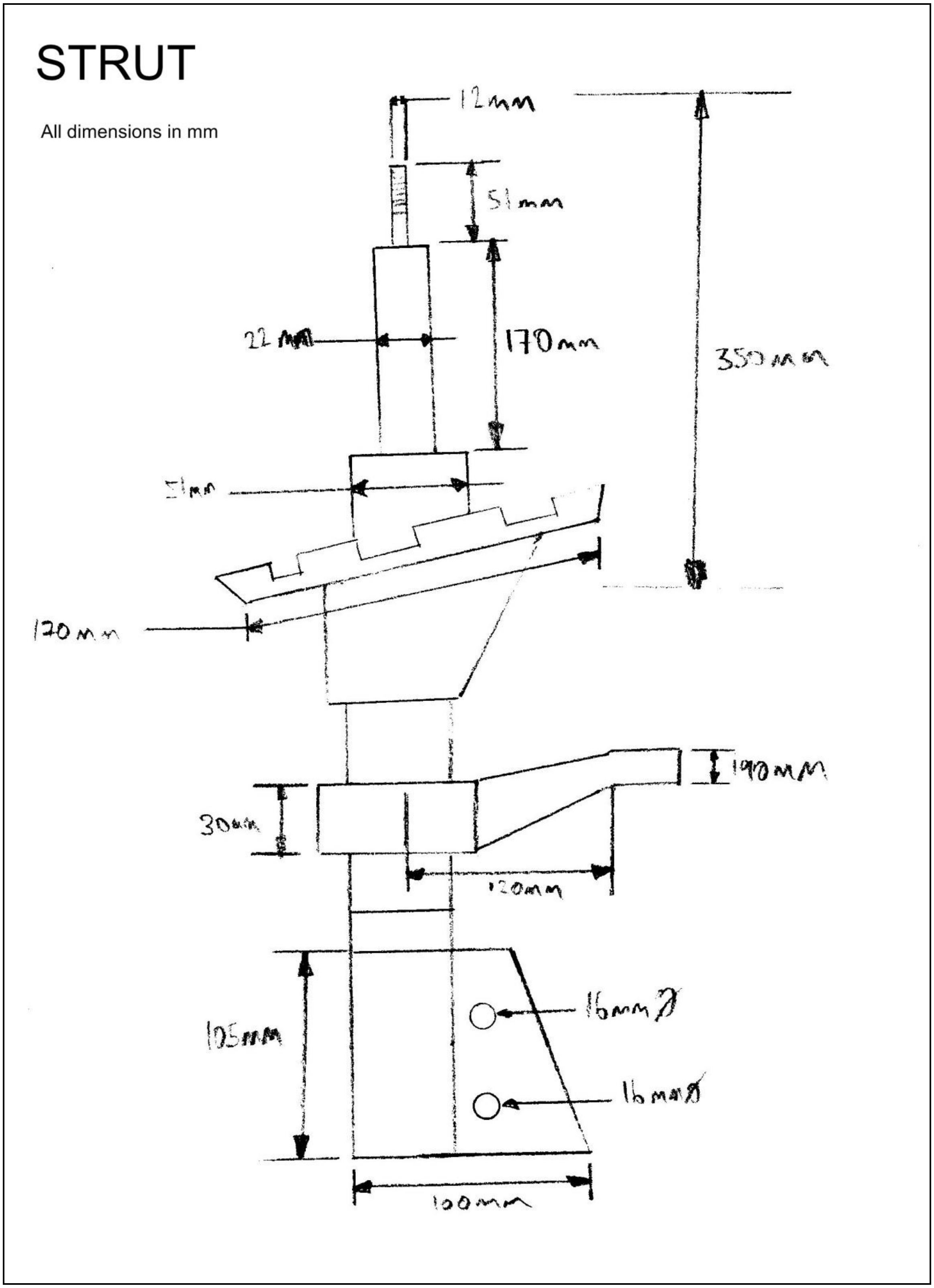
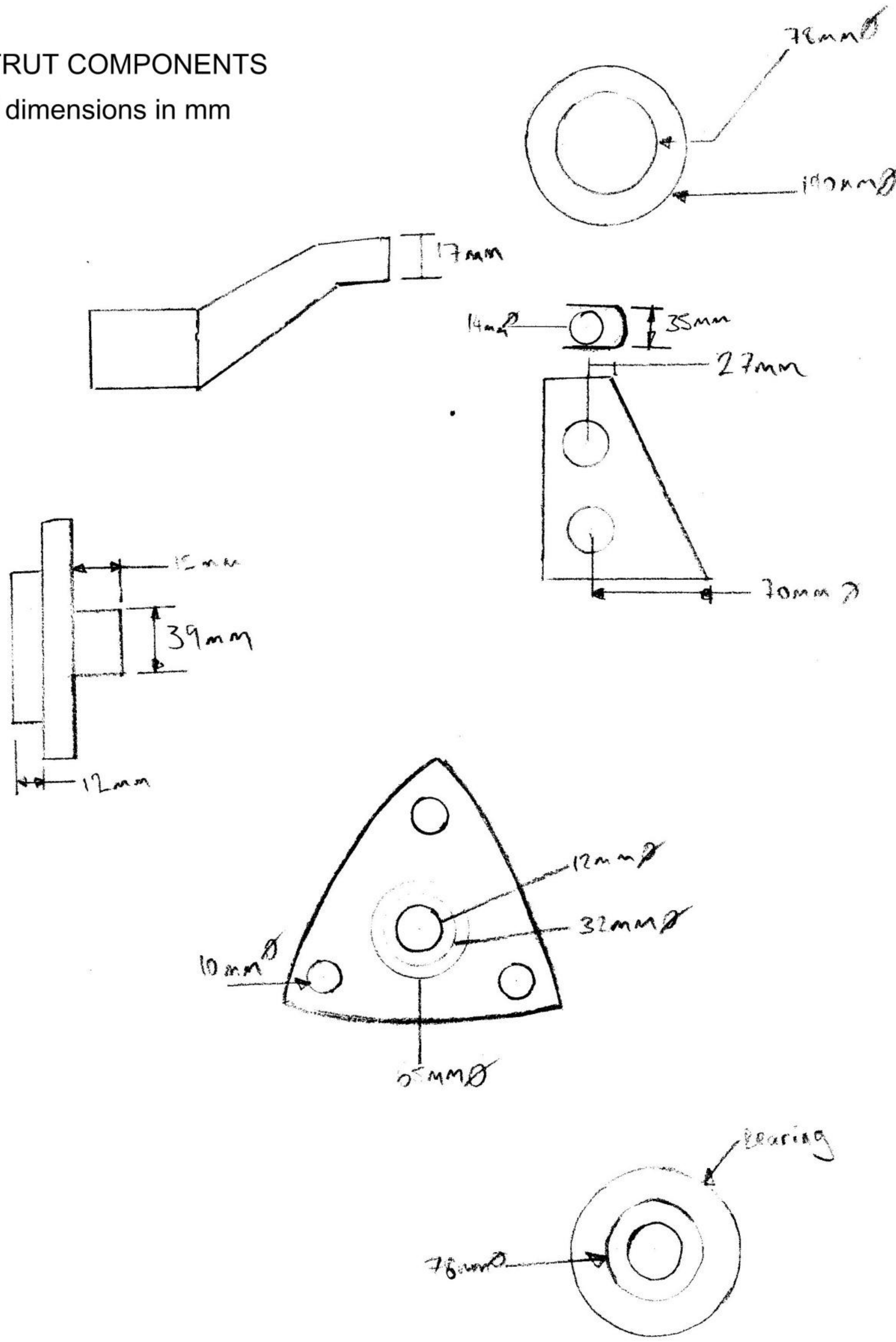
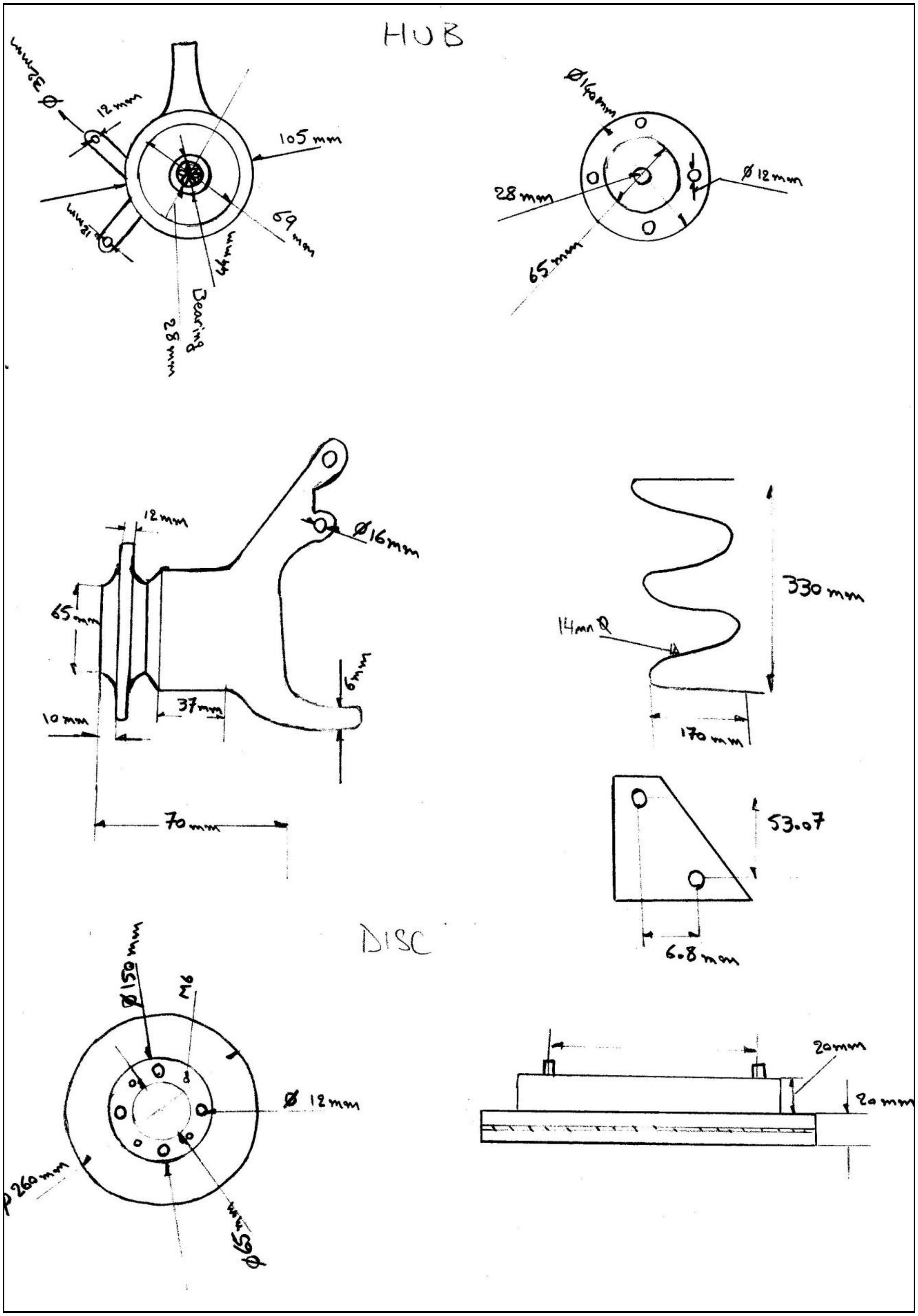
Appendix 3


STRUT
All dimensions in mm
12mm
51mm
170mm
22 MM
350mm
30mm
120mm
105mm
16mm Ø
16mmØ
100mm

STRUT COMPONENTS

All dimensions in mm

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105 mm
69 mm
Bearing
28 mm
Ø140mm
28 mm
Ø 12 mm
65 mm
12 mm
Ø16mm
65 mm
10 mm
37mm
6mm
70mm
330 mm
14mm
170 mm
53.07
6.8 mm
DISC
Ø150 mm
M6
Ø 12 mm
Ø260 mm
Ø65 mm
20mm
20 mm


205/55R16 91V
DO NOT MOUNT ON 16.5 INCH RIM.