DESIGN AND ANALYSIS OF WHEELCHAIR FOR USAGE OF HANDICAP PEOPLE

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DESIGN AND ANALYSIS OF WHEELCHAIR FOR USAGE OF HANDICAP PEOPLE

FAIZ ASWAD BIN AYOP AZMI

Report submitted in partial fulfillment of the requirements

for the award of Diploma in Mechanical Engineering

Faculty of Mechanical Engineering

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JANUARY 2012

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I hereby declare that I have checked this project report and in my opinion this project is satisfactory in terms of scope and quality for the award of Diploma in Mechanical Engineering.

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STUDENT'S DECLARATION

I hereby declare that the work in this report is my own except for quotations and summaries which have been duly acknowledged. The report has not been accepted for any degree and is not concurrently submitted for award of other degree.

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ABSTRACT

This thesis discussed the design and analysis of wheelchair for usage of handicap people. The objectives of this thesis are to design the foldable wheelchair that can be move almost all type of surfaces and to analyze the chassis of the wheelchair. Firstly, this thesis discussed about the present market concept and materials that used for wheelchair. Later, three design concepts are suggested and the concept selection using concept screening and scoring is made. The design using Solidwork software in part by part of the wheelchair is modelled. The finite element analysis is performed by Algor software. This design analysis focused on two types of chassis materials, which are aluminium alloy and stainless steel. The maximum force of 2000N was applied to chassis model. The analysis of displacement distribution, the strain and stress contour later is discussed. The result shows that stainless steel is the best material to used for chassis of wheelchair because low in displacement distribution and stress contour compared to aluminium alloy.

ABSTRAK

Tesis ini membincangkan reka bentuk dan analisis kerusi roda untuk penggunaan orang kurang upaya. Objektif tesis ini adalah untuk mereka bentuk kerusi roda dilipat yang boleh menggerakkan hampir semua jenis permukaan dan menganalisis casis kerusi roda. Pertama, karya ini membincangkan tentang konsep pasaran sekarang dan bahan-bahan yang digunakan untuk kerusi roda. Kemudian, tiga konsep reka bentuk yang disyorkan dan pemilihan konsep yang menggunakan konsep pemeriksaan dan pemarkahan dibuat. Reka bentuk dengan menggunakan perisian Solidwork dilukis bahagian demi bahagian daripada kerusi roda yang dimodelkan. Analisis unsur terhingga dijalankan oleh perisian Algor. Analisis reka bentuk ini memberi tumpuan kepada dua jenis bahan-bahan casis, yang aloi aluminium dan keluli tahan karat. Daya maksimum 2000N digunakan untuk model casis. Analisis taburan anjakan, kontur terikan dan tegasan kemudian dibincangkan. Hasilnya menunjukkan bahawa keluli tahan karat adalah bahan terbaik untuk digunakan untuk chasis kerusi roda kerana rendah dalam pengagihan anjakan dan kontur tekanan berbanding dengan aloi aluminium.

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LIST OF ABBREVIATIONS

FEA	Finite Element Analysis
Cr	Chromium
Fe	Iron
Mg	Magnesium
Mn	Manganese
Si	Silicon
Ti	Thallium
Cu	Copper
Al	Aluminium
Zn	Zinc
Ni	Nickel
C	Carbon
Mo	Molybdenum
S	Sulfur
P	Phosphorus

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF THE PROJECT

Wheelchair is one of the important things for handicap people. A wheelchair is a chair with wheels. It is designed to be replacement for walking. The device comes in variations where it is propelled by motor or by the seated occupant turning the rear wheels by hand. Often there are handles behind the seat for someone else to do the pushing.

In 1783, John Dawson of Bath, England, invented a wheelchair named after the town of Bath. Dawson designed a chair with two large wheels and one small one. The Bath wheelchair outsold all other wheelchairs throughout the early part of the 19th century.

However, the Bath wheelchair was not that comfortable and during the last half of the 19th century many improvements were made to wheelchairs. An 1869 patent for a wheelchair showed the first model with rear push wheels and small front casters. Between, 1867 to 1875, inventors added new hollow rubber wheels similar to those used on bicycles on metal rims. In 1881, the push rims for added self-propulsion were invented. In 1900, the first spoked wheels were used on wheelchairs. In 1916, the first motorized wheelchair was manufactured in London.

In 1932, engineer, Harry Jennings, built the first folding, tubular steel wheelchair. That was the earliest wheelchair similar to what is in modern use today. That wheelchair was built for a paraplegic friend of Jennings called Herbert Everest.

Together they founded Everest & Jennings, a company that monopolized the wheelchair market for many years. An antitrust suit was actually brought against Everest & Jennings by the Department of Justice, who charged the company with rigging wheelchair prices. The case was finally settled out of court.

1.2 PROBLEM STATEMENT

There have a lot of type of terrain. It can make the wheelchair user has many problems to move and doing work.

There is currently no foldable wheelchair with motor that can move freely on all surfaces. The handicap people will not worried if there do not have track for handicap people.

1.3 OBJECTIVE

The objectives of this project are:

- To design a foldable wheelchair that can move freely on all surfaces.
- To analyze the chassis of designed.

1.4 SCOPE

In this project, scope performed a range in the completion of a project. The scopes of this project are:

- To design the mechanical part of foldable wheelchair that can move freely on all surfaces using CAD software.
- To analyze the chassis of foldable wheelchair using Algor software

.

1.5 GANTT CHART

Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Task														
Data collection														
Interpreting data														
Project sketching														
Project drawing (CAD)														
Material selection														
Project analysis														
Testing design														
Finishing														
Slide preparation														
Presentation														
Report														

Table 1.1: Gantt chart

CHAPTER 2

LITERATURE REVIEW

2.1 TYPE OF WHEELCHAIR

A basic manual wheelchair incorporates a seat, foot rests and four wheels: two, caster wheels at the front and two large wheels at the back. The two larger wheels in the back usually have hand rims; two metal or plastic circles approximately 3/4" thick. The hand rims have a diameter normally only slightly smaller than the wheels they are attached to. Most wheelchairs have two push handles at the top of the back to allow for manual propulsion by a second person.

2.1.1 MANUALLY POWERED

Manual wheelchairs are those that require human power to move them. Many manual wheelchairs can be folded for storage or placement into a vehicle, although modern wheelchairs are just as likely to be rigid framed.

2.1.2 ELECTRIC-POWERED

An electric-powered wheelchair is a wheelchair that is moved via the means of an electric motor and navigational controls, usually a small joystick mounted on the armrest, rather than manual power. For users who cannot manage a manual joystick, head switches, chin-operated joysticks, sip-and-puff or other specialist controls may allow independent operation of the wheelchair

2.3 PRODUCT OF WHEELCHAIR

These are product of wheelchair that has been produce according to Figure 2.1, Figure 2.2, Figure 2.3, and Figure 2.4. This product has its own advantages and disadvantages.

The electric wheelchair A is very heavy because of it chassis as shown in Figure 2.1. It also only suitable for outdoor usage only. Furthermore, it cannot be fold and hard to store. The advantage of this product is can move at many type of surface.

The manual wheelchair is common wheelchair that use at hospital as shown in Figure 2.2. The advantage of this wheelchair is it can be fold and it can use for indoor and outdoor usage, but it only can move in limited surface only.

The electric wheelchair B is for indoor usage only as shown in figure 2.3. It cannot been fold and move at many type of terrain. The advantage of this wheelchair is more comfortable because of the cushion at the seat.

The electric wheelchair C is very heavy according to it chassis and motor as shown in Figure 2.4 because of the chassis structure. It is suitable for outdoor usage only. The advantage is it can move on many type of surface.

Figure 2.1: Electric wheelchair A

Figure 2.2: Manual wheelchair

Figure 2.3: Electric wheelchair B

Figure 2.4: Electric wheelchair C

2.4 CHARACTERISTIC OF MATERIALS

2.4.1 ALUMINIUM ALLOY

Aluminium alloys are alloys in which aluminium (Al) is the predominant metal. The typical alloying elements are copper, magnesium, manganese, silicon and zinc. There are two principal classifications, namely casting alloys and wrought alloys, both of which are further subdivided into the categories heat-treatable and non-heat-treatable. About 85% of aluminium is used for wrought products, for example rolled plate, foils and extrusions. Cast aluminium alloys yield cost effective products due to the low melting point, although they generally have lower tensile strengths than wrought alloys. The most important cast aluminium alloy system is Al-Si, where the high levels of silicon (4.0% to 13%) contribute to give good casting characteristics. Aluminium alloys are widely used in engineering structures and components where light weight or corrosion resistance is required.

Alloys composed mostly of the two lightweight metals aluminium and magnesium have been very important in aerospace manufacturing since somewhat before 1940. Aluminium-magnesium alloys are both lighter than other aluminium alloys and much less flammable than alloys that contain a very high percentage of magnesium.

2.4.2 STAINLESS STEEL

Stainless Steels are iron-base alloys containing Chromium. Stainless steels usually contain less than 30% Cr and more than 50% Fe. They attain their stainless characteristics because of the formation of an invisible and adherent chromium-rich oxide surface film. This oxide establishes on the surface and heals itself in the presence of oxygen. Some other alloying elements added to enhance specific characteristics include nickel, molybdenum, copper, titanium, aluminium, silicon, niobium, and nitrogen. Carbon is usually present in amounts ranging from less than 0.03% to over 1.0% in certain martens tic grades. Corrosion resistance and mechanical properties are commonly the principal factors in selecting a grade of stainless steel for a given application.

CHAPTER 3

METHODOLOGY

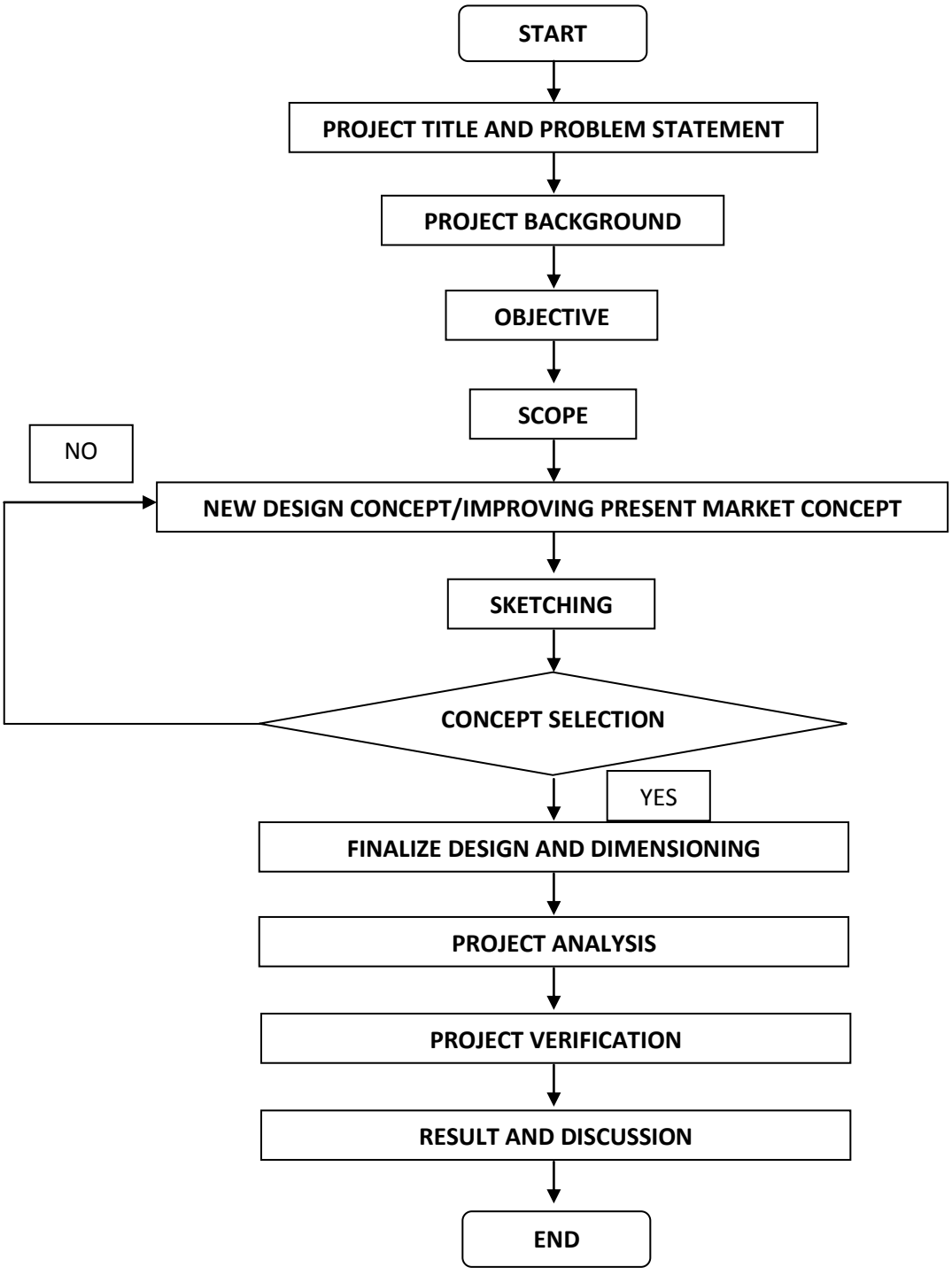
3.1 INTRODUCTION

In designing and analyzing this wheelchair, a flow of methods had to be used for complete this project. A process planning is most important and had to be charted out. This would determine the efficiency of the project to be done.

In this study, for standard wheelchairs to turn through 360 degrees the space required is 1500mm x 1500mm. The overall width of a wheelchair is approximately 635mm when it is unoccupied. Additional space is needed at each side of the chair to enable the user to propel it manually. There are many different types and sizes of manual and electric wheelchairs, some of which are modified and will take up greater space than already described, for example those with reclining backrests or elevating leg-rests.

3.2 FLOW CHART

In this part, will be explained about the flow of the project. After getting all data, concept sketching is the most important for finalize the design. After that the design will draw in Solidwork software and analysis part will analyze in Algor software.



3.3 DRAWING

The drawings are dividing into two categories:

- Sketching: all idea will be sketch on a paper. This step will produce three sketching and choose it by scoring and screening process.
- Solidwork: when choosing one concept, it will transfer into solidwork for 3D process. It also for getting the correct dimension for this wheelchair.

3.4 SKETCHING AND DRAWING SELECTION

From the existing idea, three concepts had been come out to select as a final design. The drawing selection will evaluate according the advantage and disadvantage.

3.4.1 CONCEPT 1

This wheelchair using four big wheel to increase the stability and to increase the ability for moving on different surface as shown in Figure 3.1.

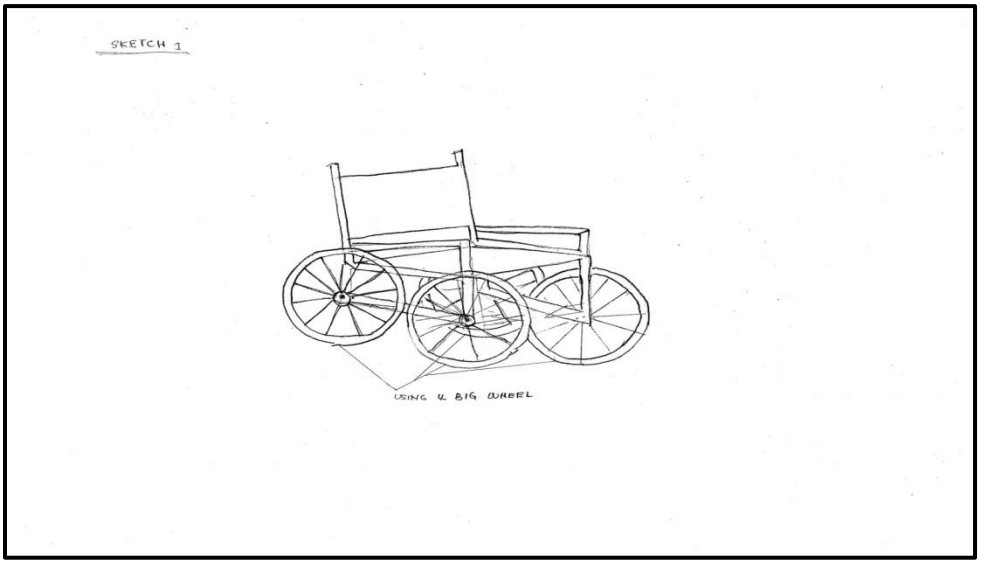


Figure 3.1: Concept 1

3.4.2 CONCEPT 2

This wheelchair using belting and pulley for moving and able to reduce force that acting on the belting and surface as shown in Figure 3.3.

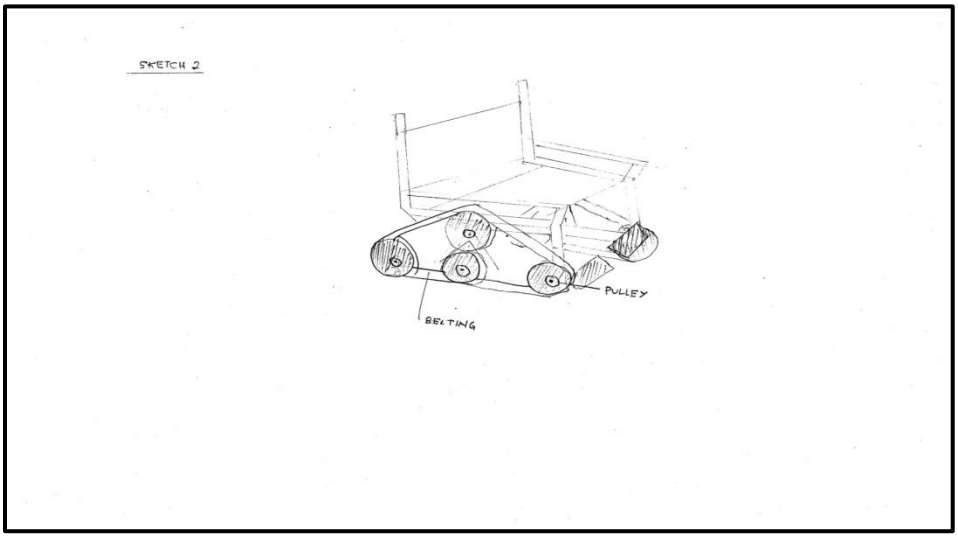


Figure 3.2: Concept 2

3.4.3 CONCEPT 3

This design quite same with concept 2, using belting and pulley as a wheel, but the placed of pulley is different for increase the ability to move on different surface as shown in Figure 3.4.

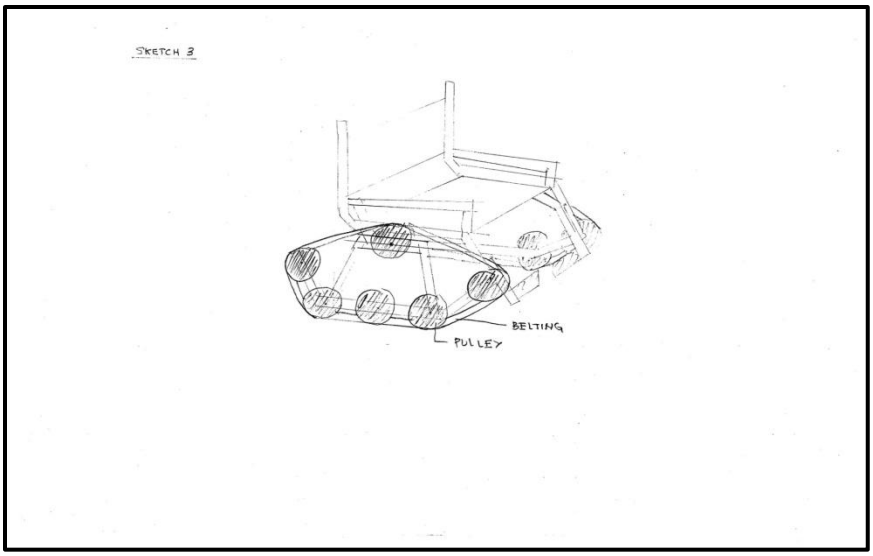


Figure 3.3: Concept 3

3.5 SCREENING AND SCORING PROCESS

This process is for selecting the final concept to transfer into Solidwork drawing.

3.5.1 CONCEPT SCREENING

Concept screening is based on a method developed by the late Stuart Pugh in the 1980s and is often called Pugh Concept Selection as shown in Table 3.1. The purposes of this stage are to narrow the number of concept quickly and to improve the concept.

Table 3.1: Concept screening

	CONCEPT			
SELECTION CRITERIA	1	2	3	REFERENCE
Foldable	+	+	+	0
Stability	-	0	+	0
Enable to move any	-	0	+	0
surface	0	0	+	0
Safety				
Sum +'s	1	1	4	0
Sum 0's	1	3	0	4
Sum –'s	2	0	0	0
Net score	-1	1	4	0
Rank	3	2	1	3
Continue?	NO	YES	YES	

3.5.2 CONCEPT SCORING

Concept scoring is used when increase resolution will better differentiate among competing concepts. In this stage, the team weights and relative importance of the selection criteria and focuses on more refined comparisons with respect on each criterion. The concept scores are determined by the weighted sum of the ratings.

Table 3.2: Concept scoring

SELECTION CRITERIA	WEIGHT (%)	CONCEPT			
		2		3	
		RATING	WEIGHTED SCORE	RATING	WEIGHTED SCORE
Foldable.	25	4	1	5	1.25
Stability.	20	3	0.6	5	1
Enable to move any surface.	20	4	0.8	4	0.8
Safety	35	2	4	4	1.4
	Total score		3.10		4.45
	Rank		2		1
	Continue?		NO		YES

From the concept screening and scoring table, the advantage and disadvantage of the design can be outlined. According to the table, concept 3 was selected to continue the design.

3.6 COMPUTER AIDED DESIGN DRAWING (SOLIDWORK)

After design has been selected, the next step in designing process is dimensioning according to Figure 3.5. The design is separated into part by part and the dimensioning process is firstly sketched on the paper. The dimensioning is base on relevant dimension and also referring the existence wheelchair.

After dimensioning, the drawing of the design is drawn using Solidwork application as shown in Figure 3.4. At this stage, solid modelling method is used. Part by part solid modelling create according to the dimension done before, after all part create, the 3D model is assemble with each other based on design.

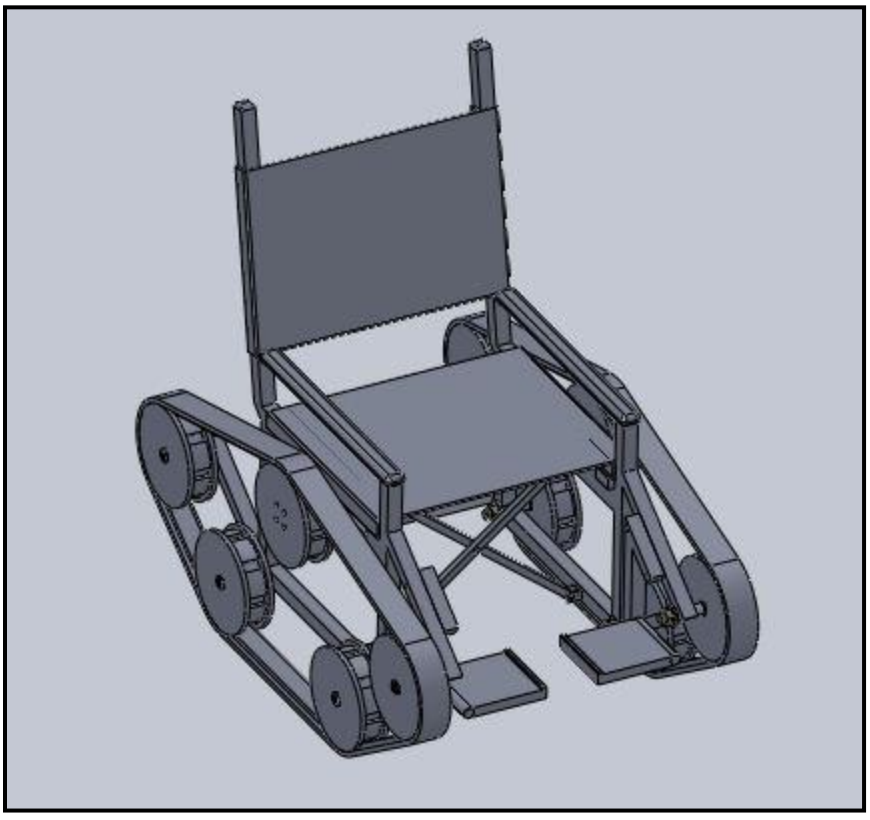


Figure 3.4: Solidwork drawing

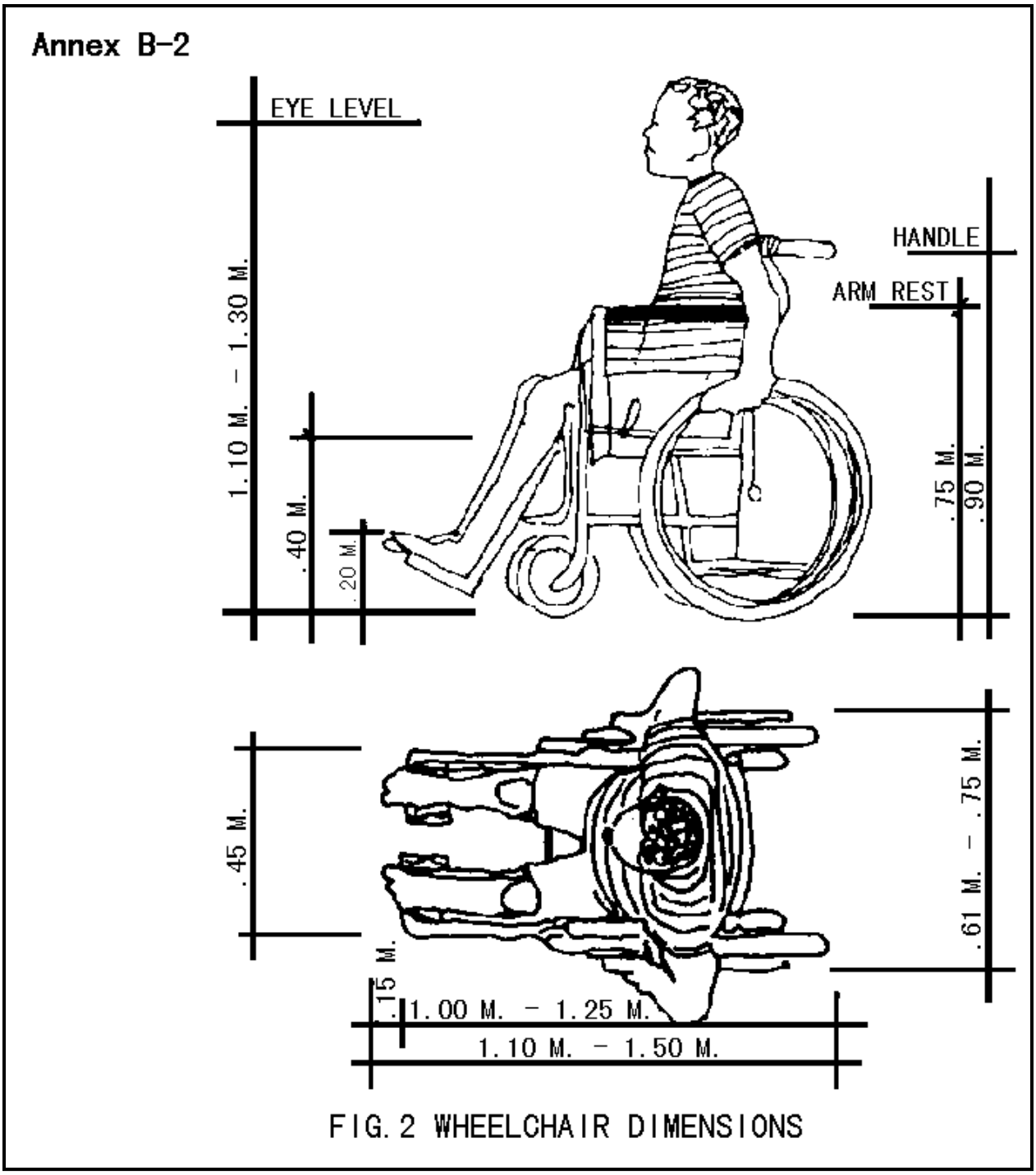


Figure 3.5: Wheelchair dimension

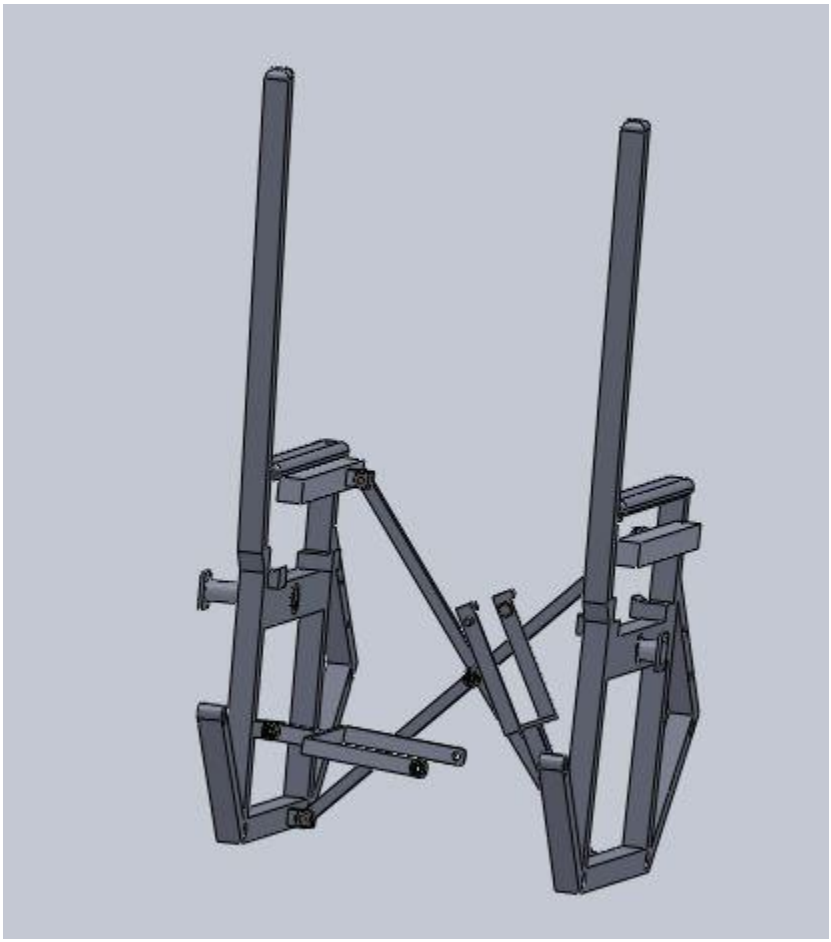


Figure 3.6: Foldable part

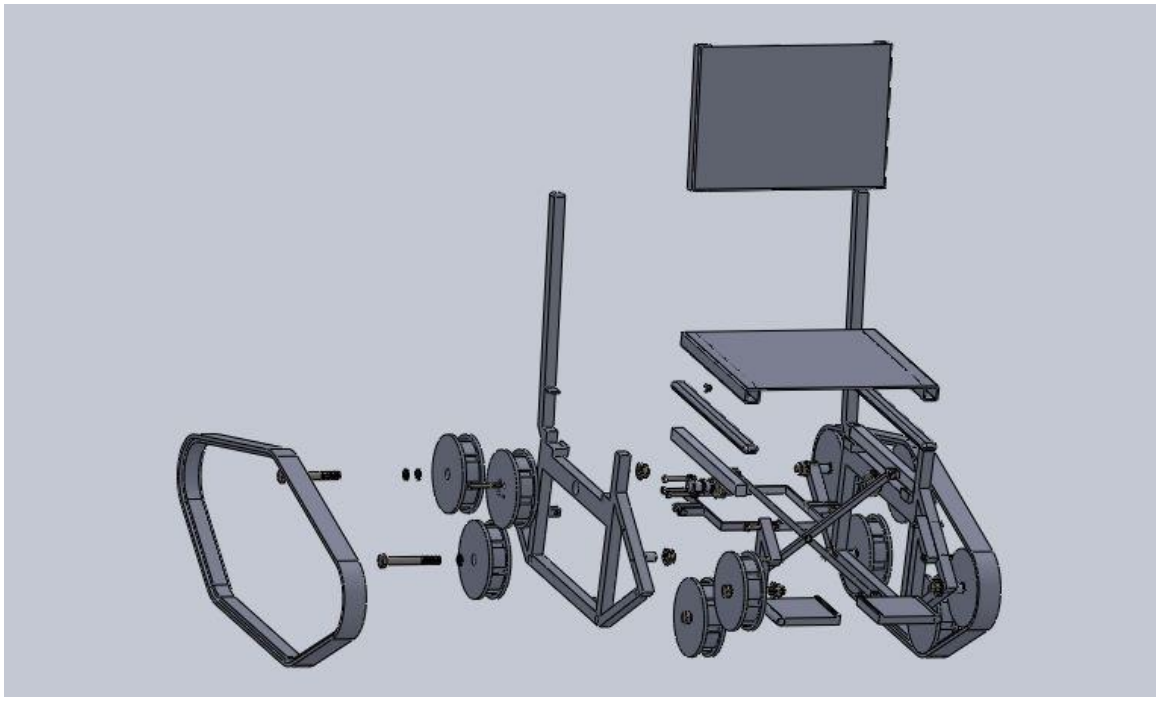


Figure 3.7: Exploded view

3.7 ANALYZING THE WHEELCHAIR CHASIS USING ALGOR

The finite element model is developing using the brick type element as shown in Figure 3.8. The linear static analysis is considered to determine the stress with linear material. Material is most important role to analysis the chassis of this wheelchair. This analysis uses two type of material. It is aluminium and stainless steel as shown in Table 3.3 and Table 3.5. The force was loaded at the seat of wheelchair. The force is 50N to 60N due to weight of the user. The direction of forces shown in Figure 3.8.

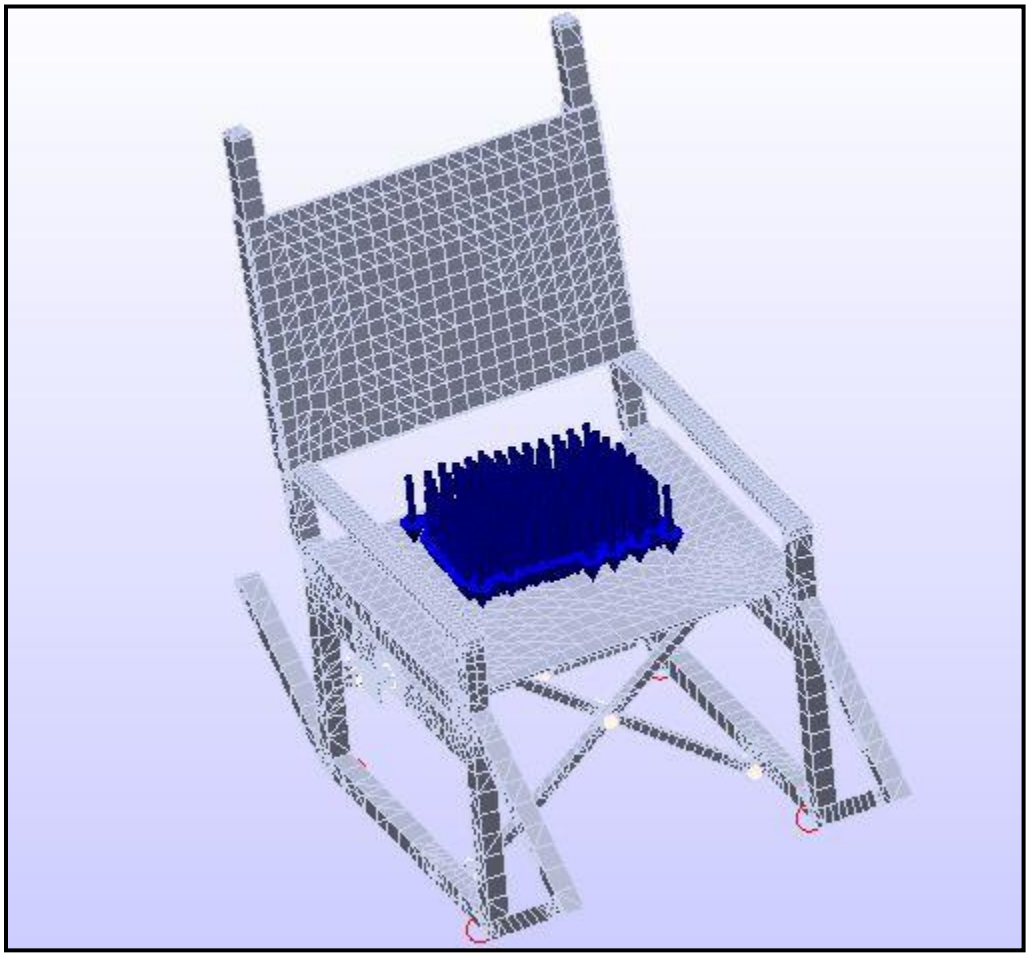


Figure 3.8: Brick element and direction of forces

Material properties play an important role in the result of the FE method. The material properties are one of the major inputs. The material information of AA6063-T6 is listed Table 3.3 and Table 3.4.

Table 3.3: Mechanical properties of Aluminium Alloys 6063-T6

Properties	Value and unit
Ultimate tensile strength	195MPa
Density	2.7 g/cm3
Modulus of elasticity	69.5GPa
Shear strength	150 MPa
Yield strength (0.2% offset)	160 MPa
Melting point	600 °C
Elongation	14%

Table 3.4: Typical Composition of Aluminium Alloys 6063-T6

Element	Value
Cr	0.1
Fe	0.35 max
Mg	0.45 - 0.9
Mn	0.1 max
Si	0.2
Ti	0.1 max
Cu	0.1max
Al	Balance
Zn	0.1 max

Material properties play an important role in the result of the FE method. The material properties are one of the major inputs. The material information of Stainless Steel (AISI 317) is listed Table 3.5 and Table 3.6.

Table 3.5: Mechanical properties of Stainless Steel (AISI 317)

Properties	Value and unit
Ultimate tensile strength	70 MPa
Density	8.0 g/cm3
Modulus of elasticity	200 GPa
Shear strength	152 MPa
Yield strength (0.2% offset)	205 MPa
Melting point	1454 °C
Elongation	35%

Table 3.6: Typical Composition of Stainless Steel (AISI 317)

Element	Value
Ni	11-14
Cr	18-20
C	0.08 max
Mo	3-4
Fe	Balance
Mn	2 max
Si	1 max
S	0.03 max
P	0.04 max

CHAPTER 4

RESULT AND DISCUSSION

4.1 INTRODUCTION

Finite Element Analysis (FEA) of wheelchair chassis was tested using FEMPRO ALGOR software. One wheelchair chassis was analyzed using two different materials.

4.2 FINITE ELEMENT ANALYSIS (FEA) ON WHEELCHAIR CHSSIS USING ALGOR.

Finite Element Analysis (FEA) has been tested on these wheelchair chassis. The mass was considered based on wheelchair user's weight. The total mass is 200kg because the consideration of safety factor. The user's weight preferred for using this wheelchair is 100kg. The results are separate in three categories which is stress contour, strain contour and displacement distribution. Result was taken for two types of materials.

4.3 RESULTS

4.3.1 ALUMINIUM ALLOY

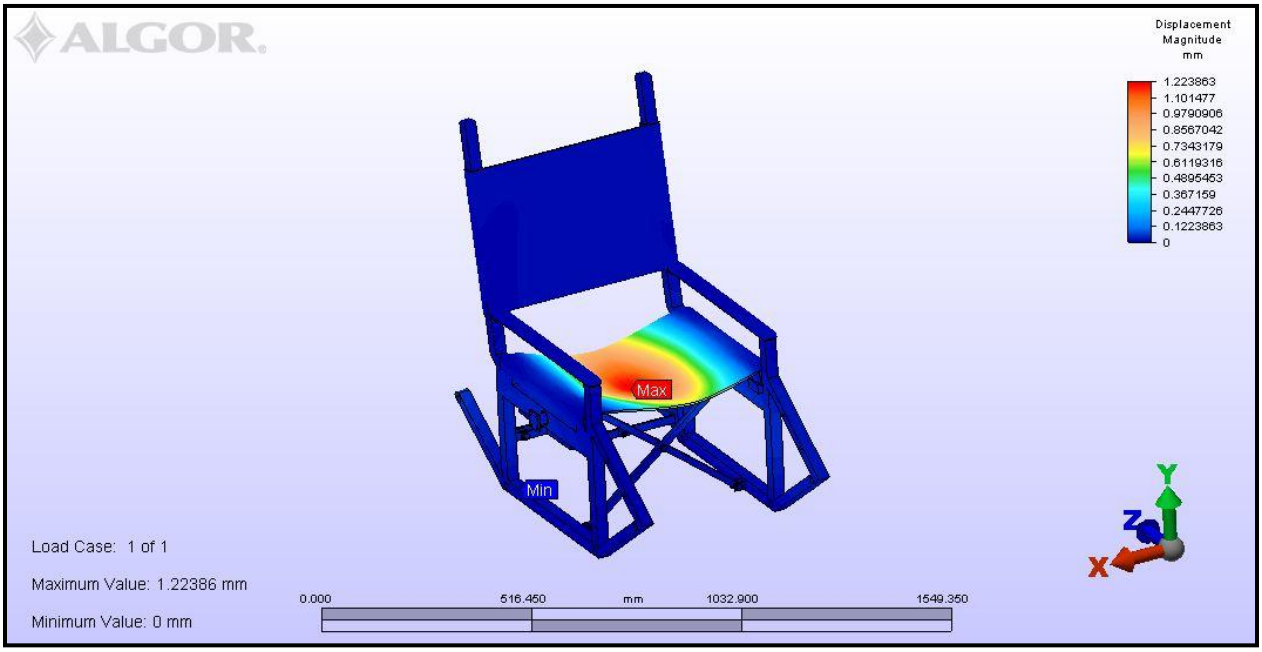


Figure 4.1: Displacement distribution

From the analysis that has perform, the result of displacement distribution of wheelchair design as shown in Figure 4.1. In this analysis observed the maximum displacement is 1.23 mm. the result show high displacement is occur at the center of seat of the wheelchair.

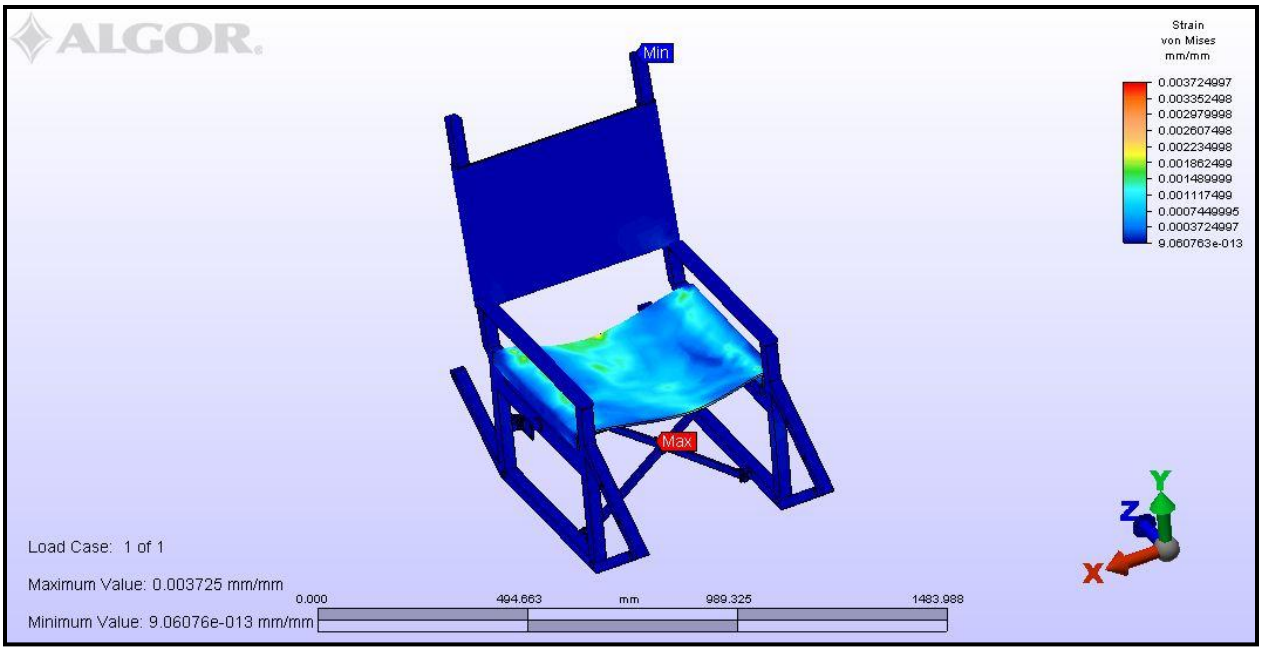


Figure 4.2: The strain contour

From the analysis that have been perform the strain contours of wheelchair design as shown in Figure 4.2. In the analysis, it is observe the maximum strain is 0.0037 mm/mm and the minimum strain is 9.0608e-013 mm/mm. The result shown that the high strain at the foldable part and the low strain is at the top of the chassis.

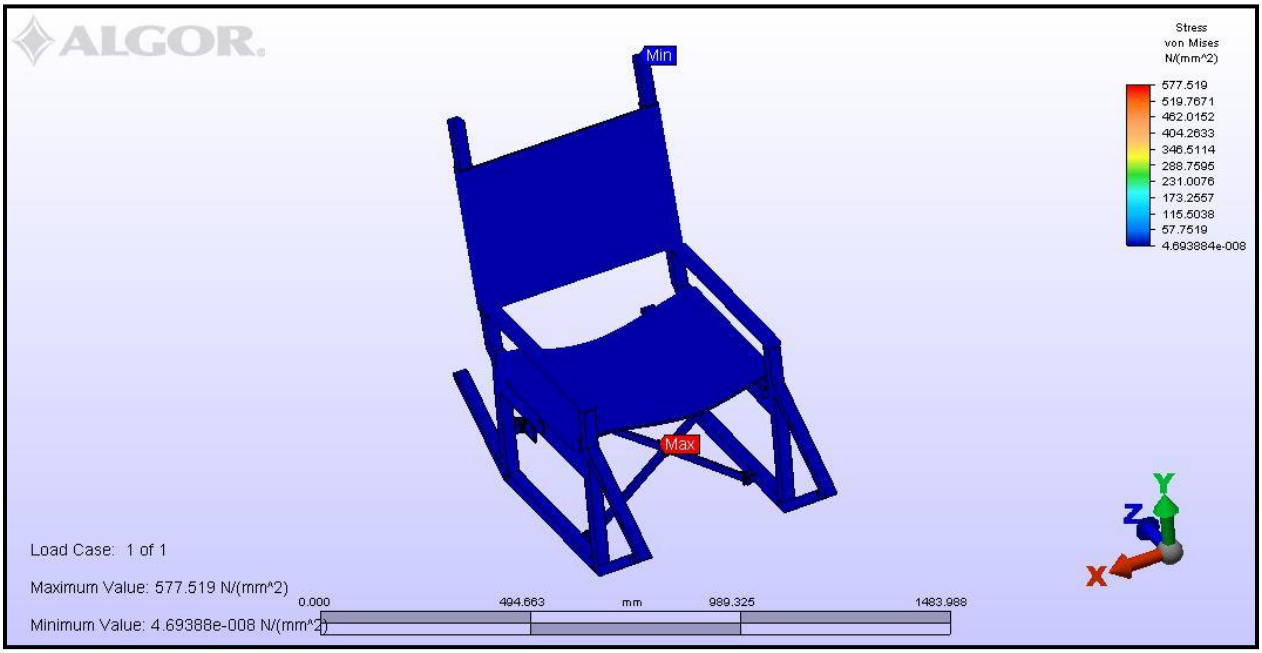


Figure 4.3: The stress contour

From the analysis that have been perform the stress contours of wheelchair design as shown in Figure 4.3. In the analysis, it is observe the maximum stress is 577.5 N/mm^2) and the minimum stress is 4.69e-008 N/(mm^2). The result shows that the high stress at the foldable part and the low stress is at the top of chassis.

4.3.2 STAINLESS STEEL

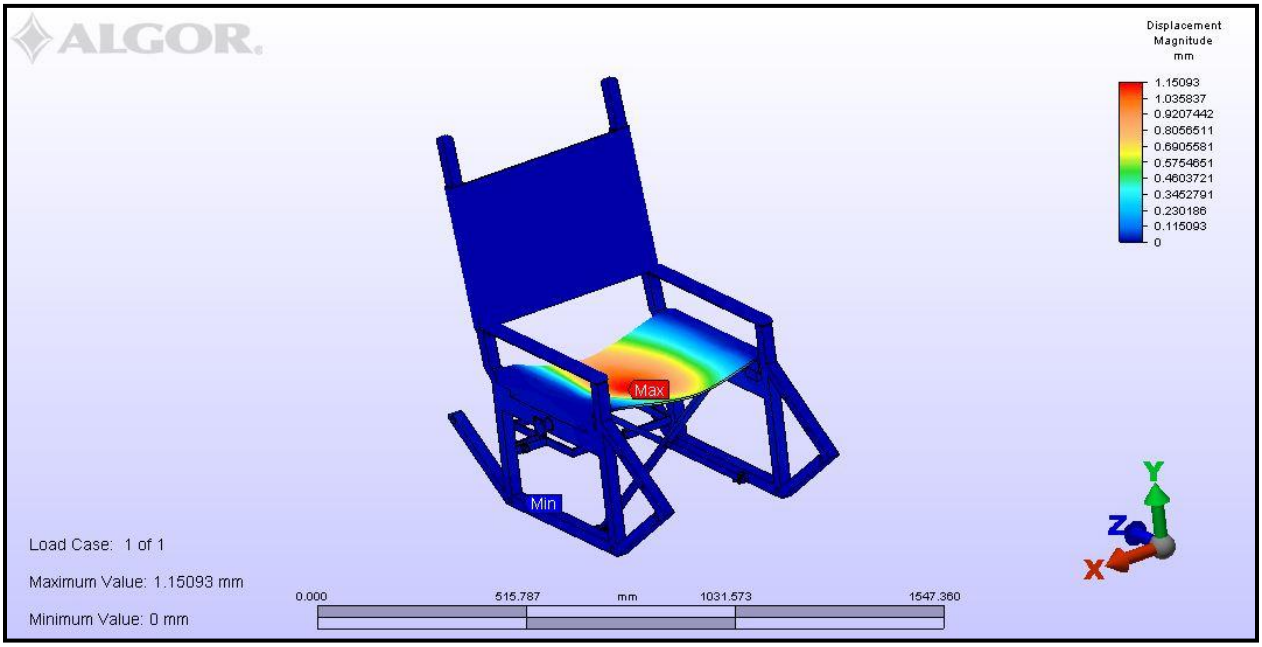


Figure 4.4: Displacement distribution

From the analysis that has performed the result of displacement distribution of wheelchair design as shown in Figure 4.4. In this analysis observed the maximum displacement is 1.15 mm. the result show high displacement is occur at the center of seat of the wheelchair.

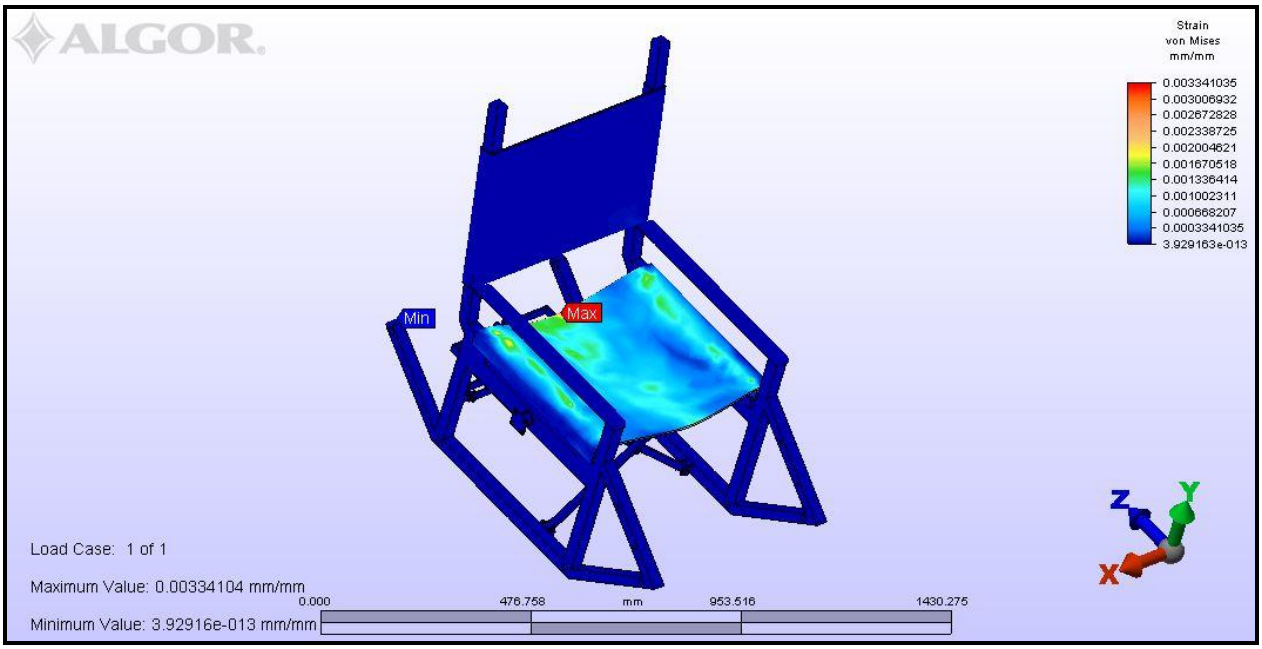


Figure 4.5: The strain contour

From the analysis that have been perform the strain contours of wheelchair design as shown in Figure 4.5. In the analysis, it is observe the maximum strain is 0.0033 mm/mm and the minimum strain is 3.9292e-013 mm/mm. The result shown that the high strain at the seat of the wheelchair and the low strain is at the support part of the chassis.

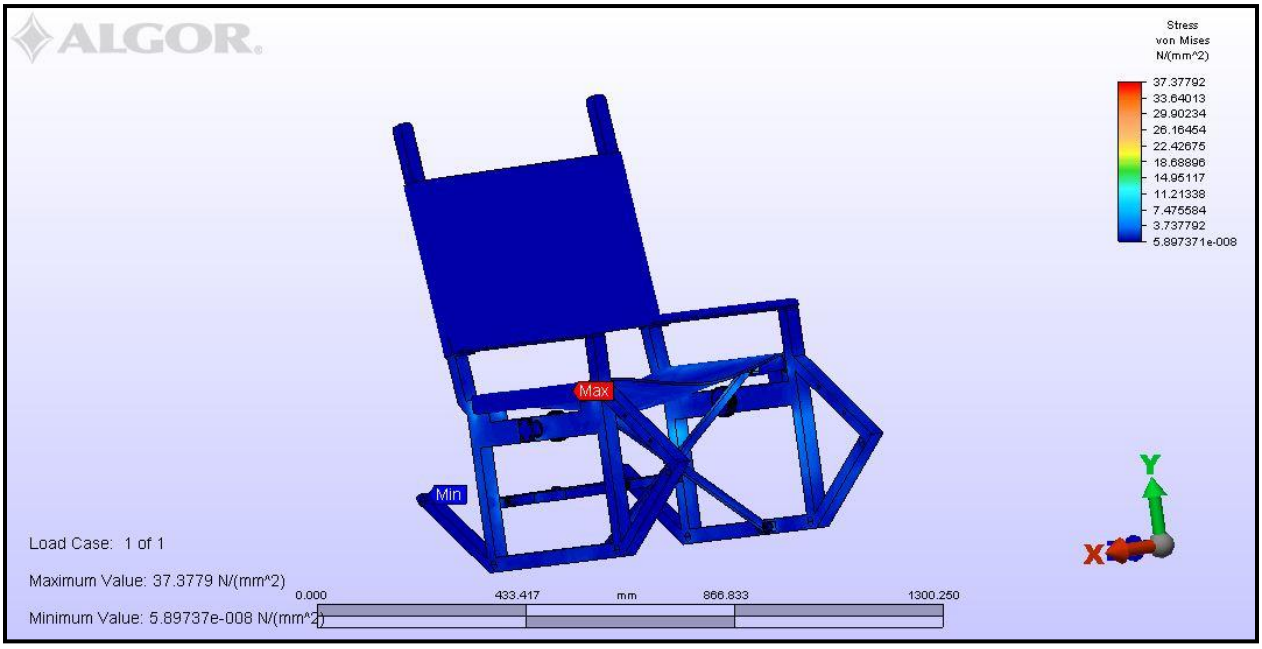


Figure 4.6: The stress contour

From the analysis that have been perform the stress contours of wheelchair design as shown in Figure 4.6. In the analysis, it is observe the maximum stress is 37.3779 N/mm^2) and the minimum stress is 5.8974e-008 N/(mm^2). The result shows that the high stress at the foldable part and the low stress is at the top of chassis.

4.4 DISCUSSION

4.3.1 COMPARISON RESULT BETWEEN THE MATERIALS

In this section, overall result comparing with two different material, aluminium and stainless steel. The result measure with the same force applied. The aluminium has high maximum stress compared to stainless steel. All these design are not fail due to maximum stress smaller than the yield strength.

The analysis tested with 200 kg but according to safety factor of two, this wheelchair is preferred only for people with 100 kg and below. If the user's weight more than 200 kg, it will increase the stress contour and displacement distribution of this wheelchair. It can cause cracking at the joint and the chassis will be bend.

Comparing the both materials, stainless steel is most suitable material for fabricate this wheelchair. The result shows the displacement magnitude, maximum and minimum stress, and maximum and minimum strain of the wheelchair. The comparison of two materials of chassis listed in Table 4.1 below.

4.3.2 ANALYSIS RESULT OF WHEELCHAIR'S CHASSIS

Figure 4.1: Result table

Materials / Parameters	Aluminium Alloy	Stainless steel
Displacement magnitude, (mm)	1.22386	1.15093
Max stress,[N/(mm^2)]	577.519	37.3779
Min stress,[N/(mm^2)]	4.69388e-008	5.89737e-008
Max strain, (mm/mm)	0.003735	0.00334104
Min strain, (mm/mm)	9.06076e-013	3.92916e-014

CHAPTER 5

CONCLUSION AND RECOMMANDATION

As a conclusion, this project is successful due to the objective of this project. This project has been finish the foldable wheelchair design using CAD software and analyzed the chassis using Algor software. The result of this project already listed.

One design of wheelchair has come out from this project and it has been analyze with two different chassis material. The result of both materials does not fail.

As a recommendation, use another software to analyze this project because it has some warning when using Algor software. Analyze all the part and joining section for getting the better result. The movement of wheelchair at different degrees of surfaces also should be analyzing. The forces must put at more part for make sure the forces are uniform. Then, add more type of material when analyze the chassis of wheelchair for getting the best material selection to fabricate this product.

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http://www.articlesbase.com/cars-articles/car-rim-sizes-and-wheel-materials-534955.html

Design guide for wheelchair accessible housing

http://www.portsmouth.gov.uk/media/HHSC_wheelchairacchousing.pdf

Aluminium alloy

http://en.wikipedia.org/wiki/Aluminium_alloy

Stainless Steel

http://www.materialsengineer.com/E-Stainless-Steel.htm

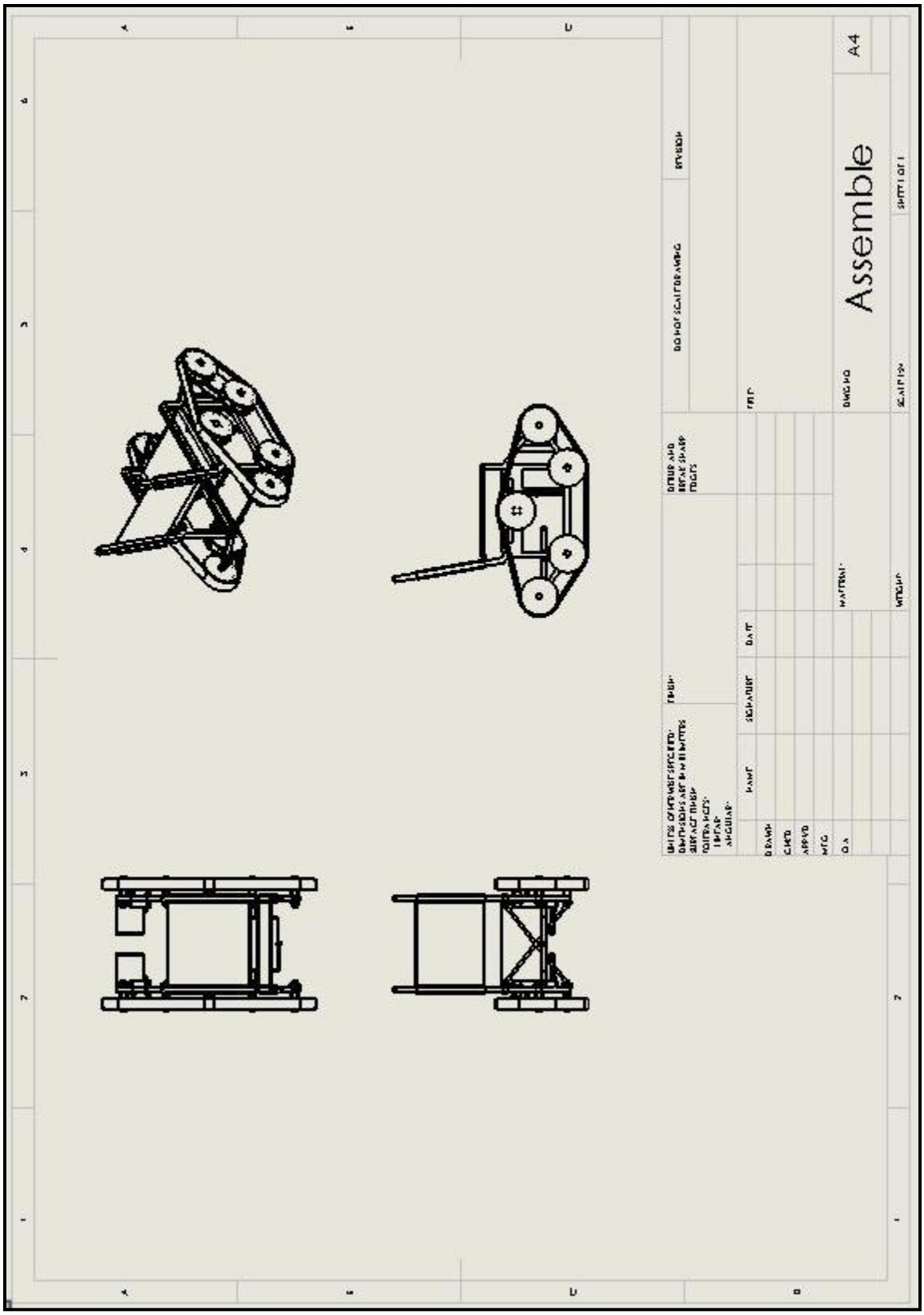
APPENDICES A

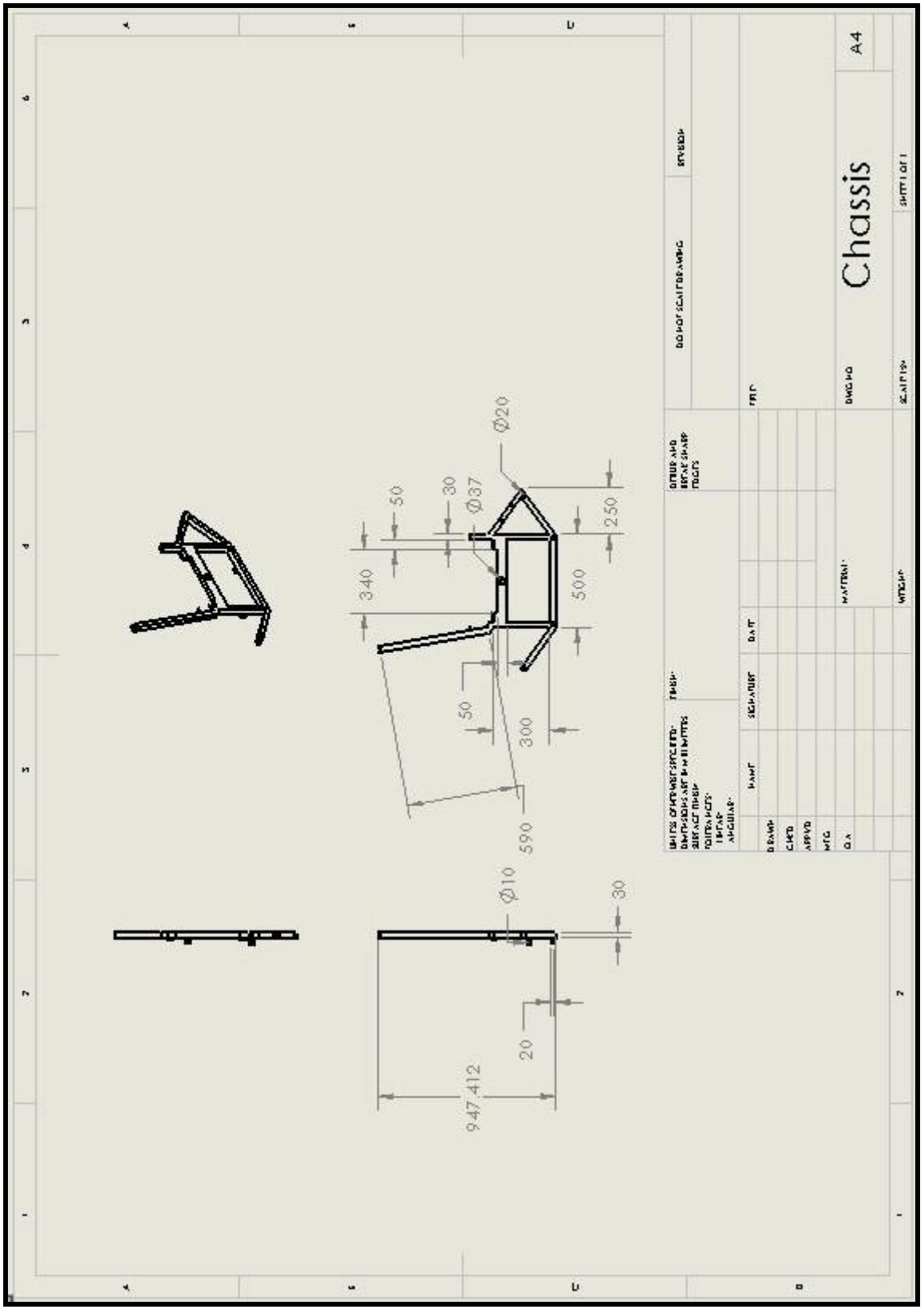
GANTT CHART

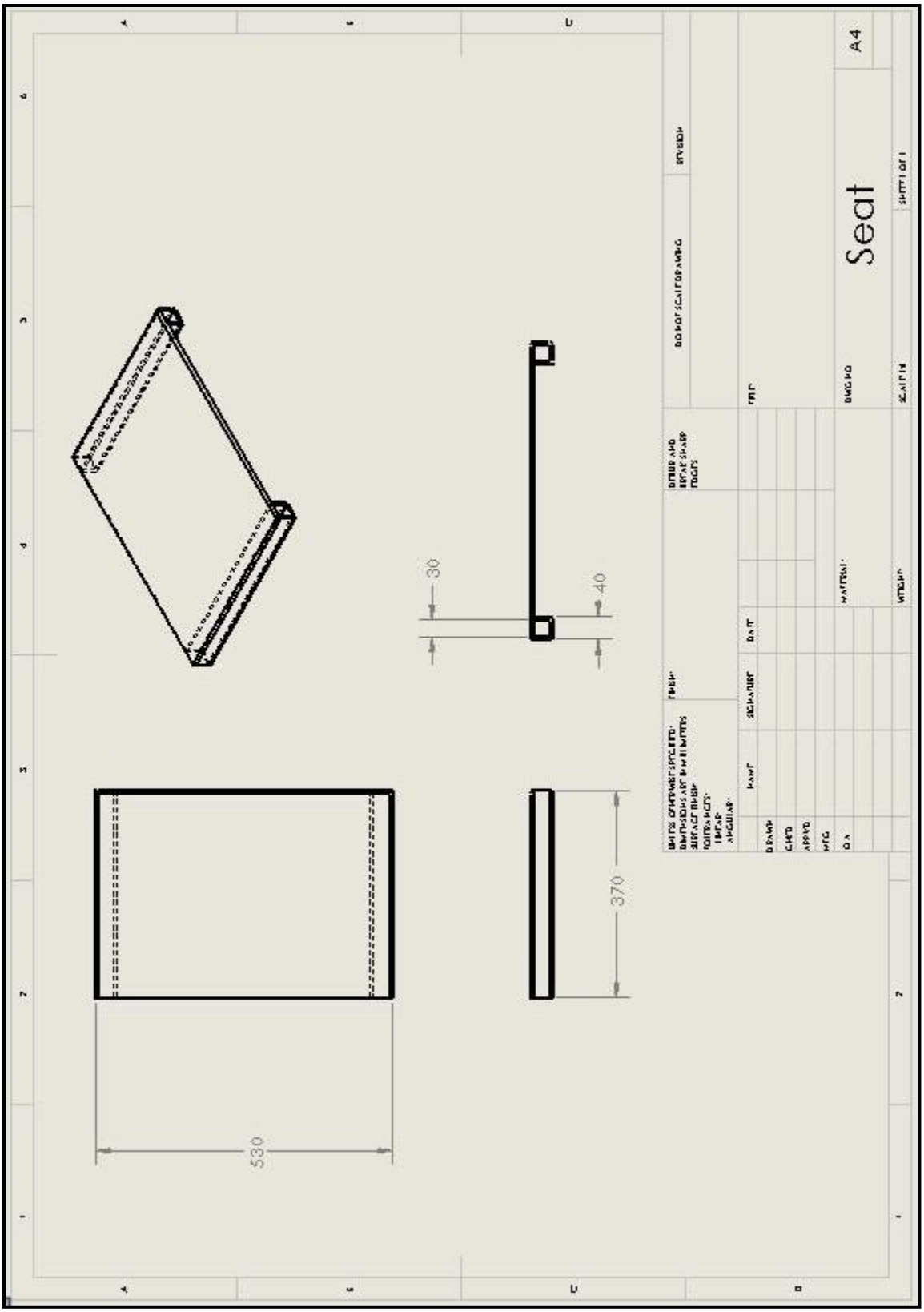
Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Task														
Data collection														
Interpreting data														
Project sketching														
Project drawing (CAD)														
Material selection														
Project analysis														
Testing design														
Finishing														
Slide preparation														
Presentation														
Report														

APPENDICES B

CAD DRAWING


Assemble
A4


Chassis
A4
Ø20
Ø37
30
50
340
500
250
50
300
590
Ø10
30
20
947.412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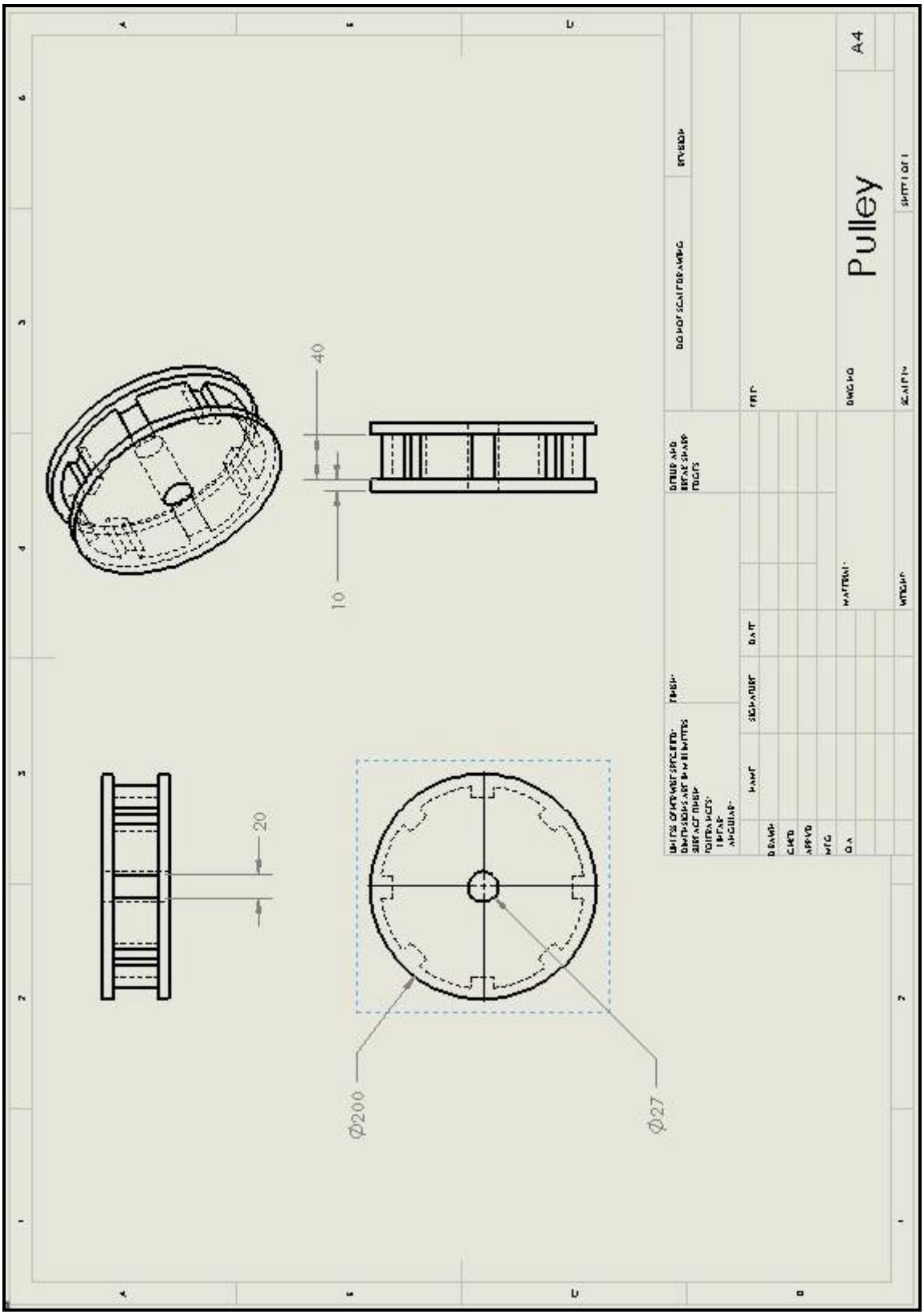
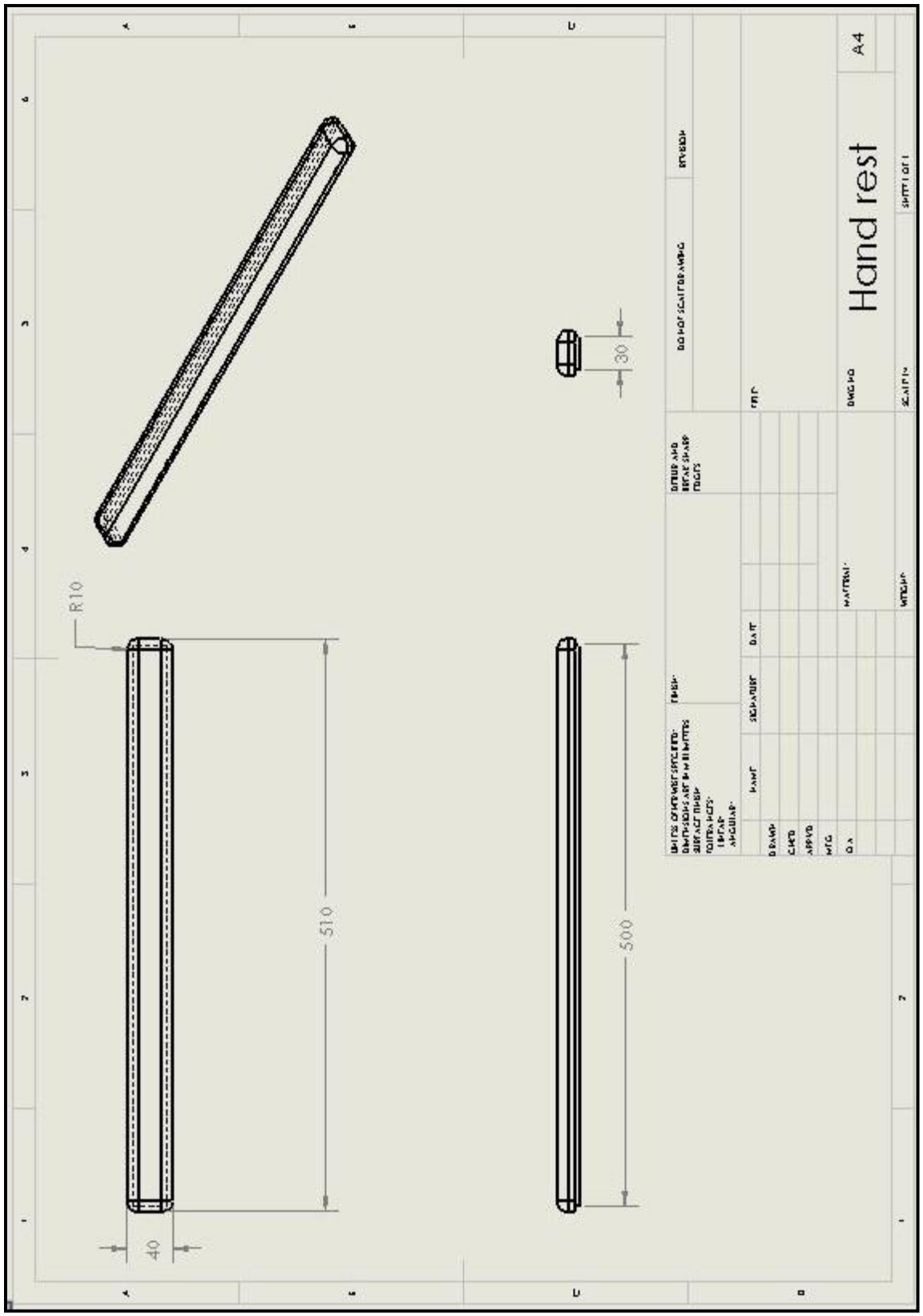
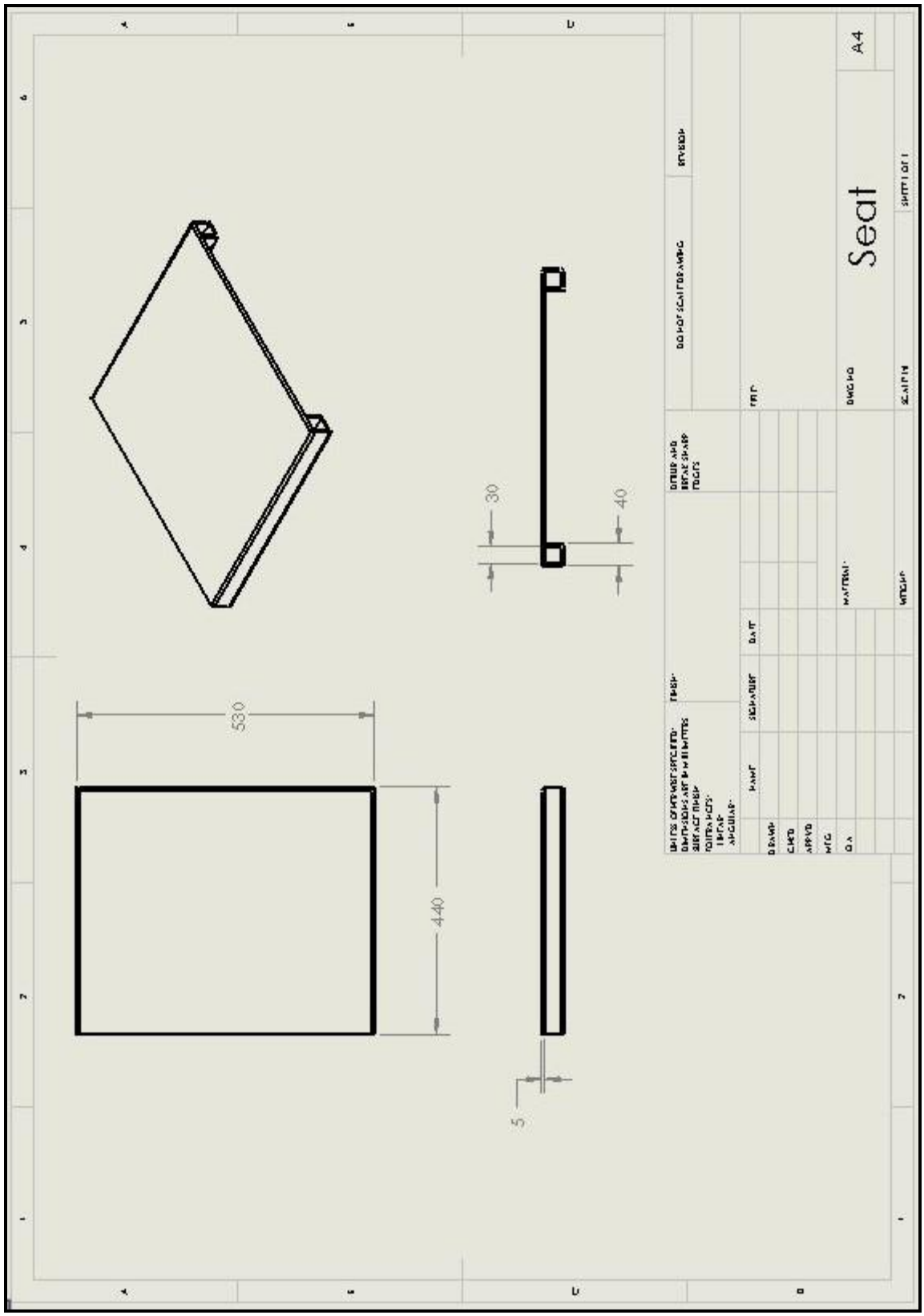
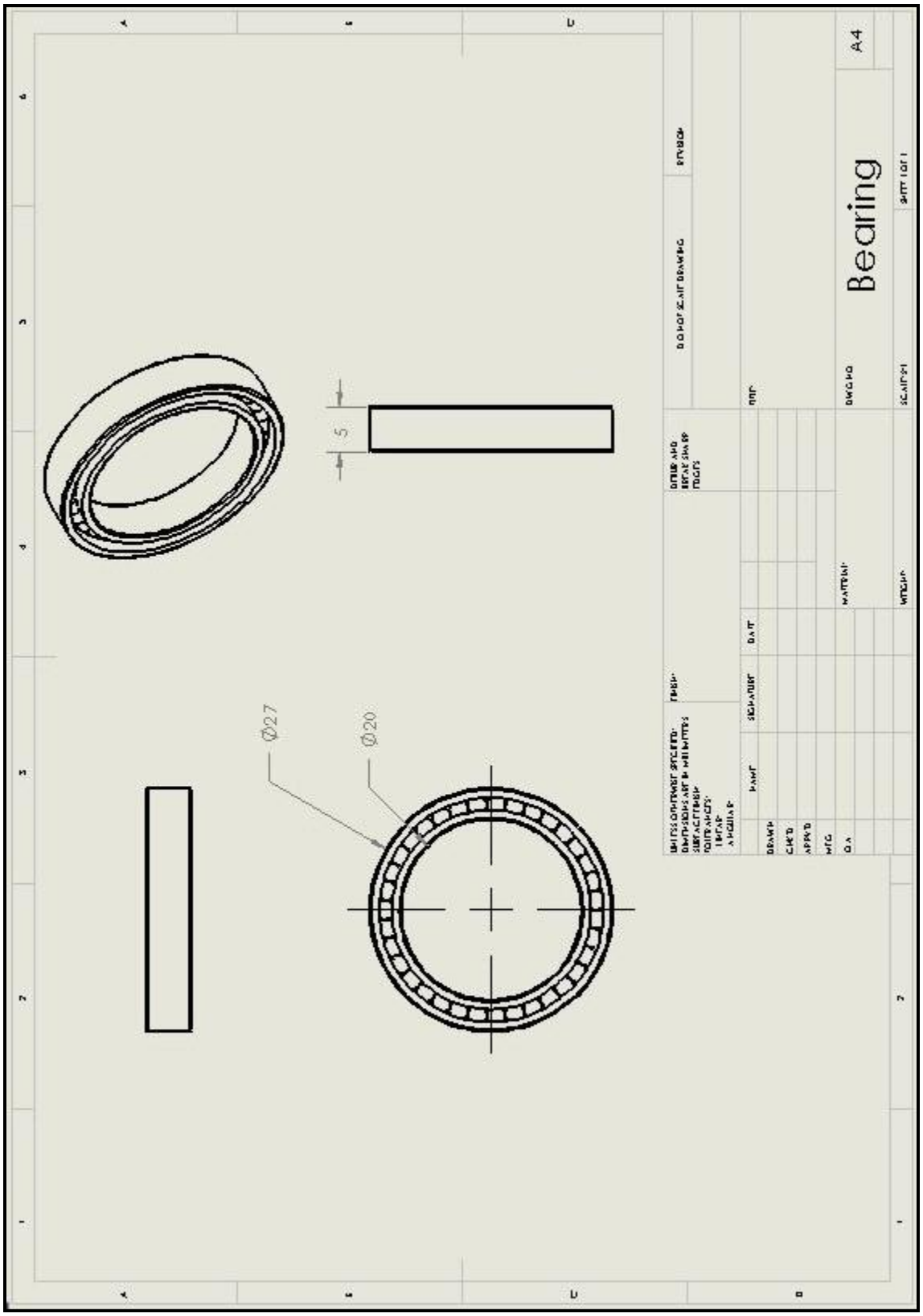
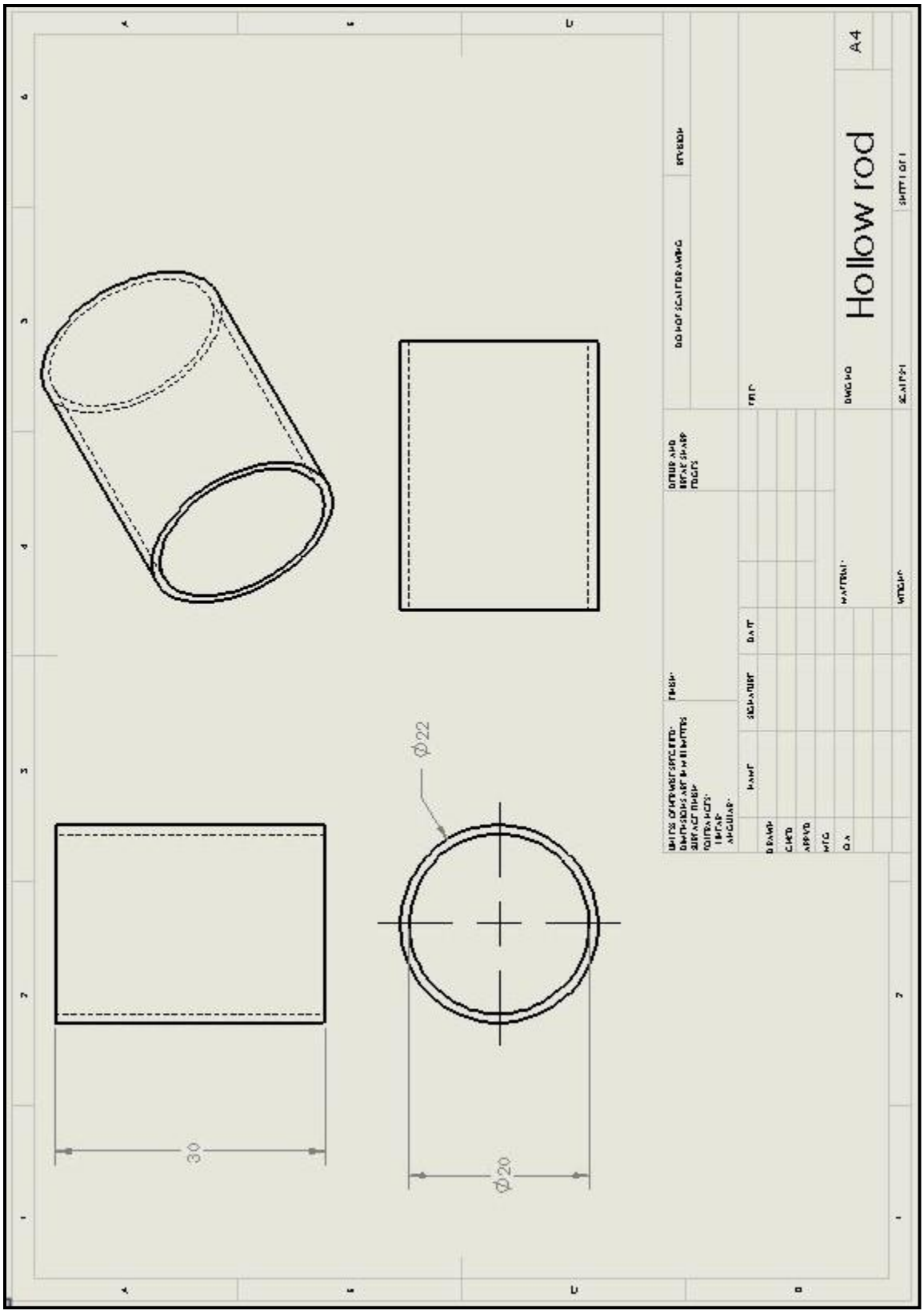
530
370
30
40

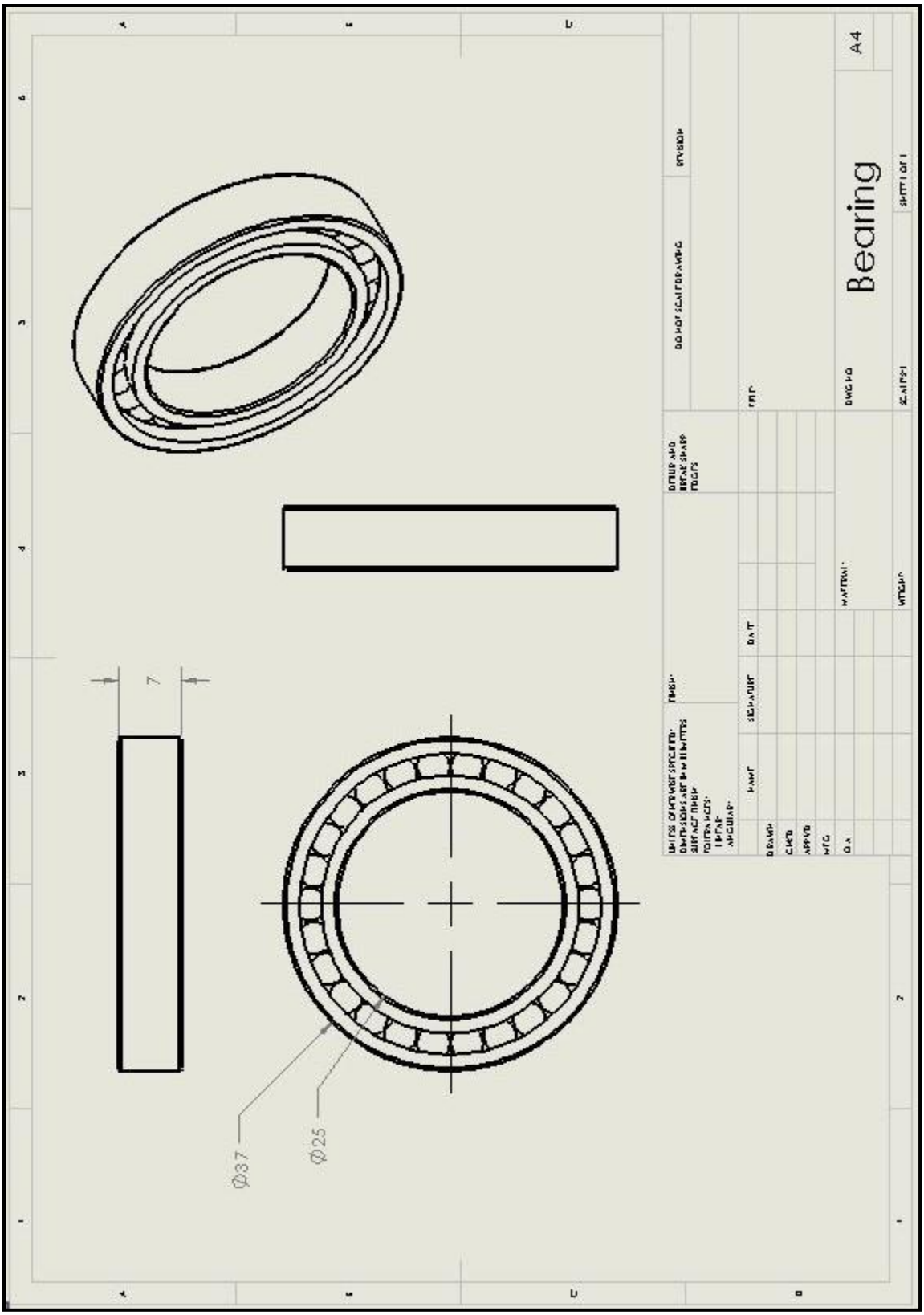

40
10
20
Ø200
Ø27
Pulley
A4

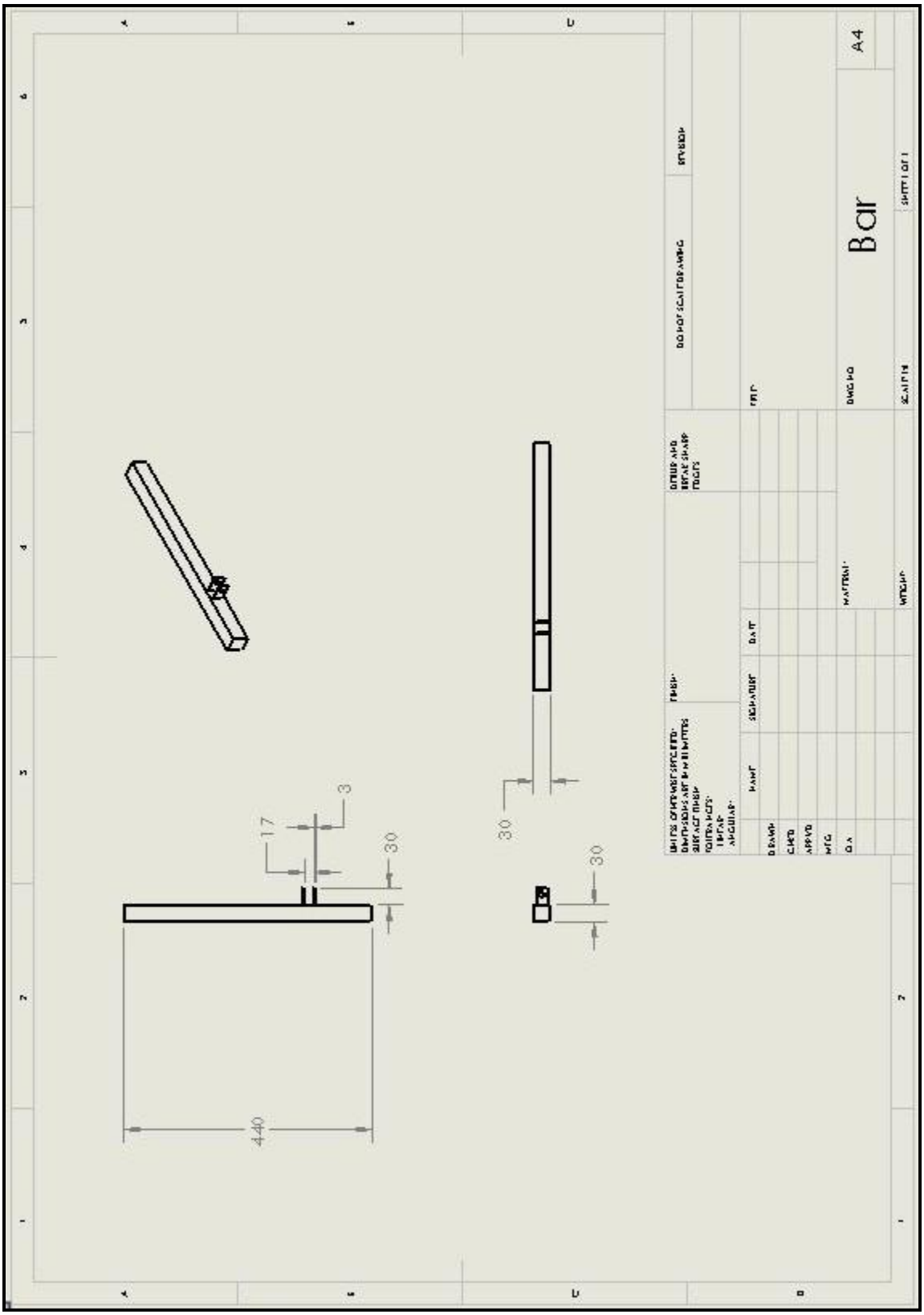

Hand rest
A4
R10
510
40
500
30

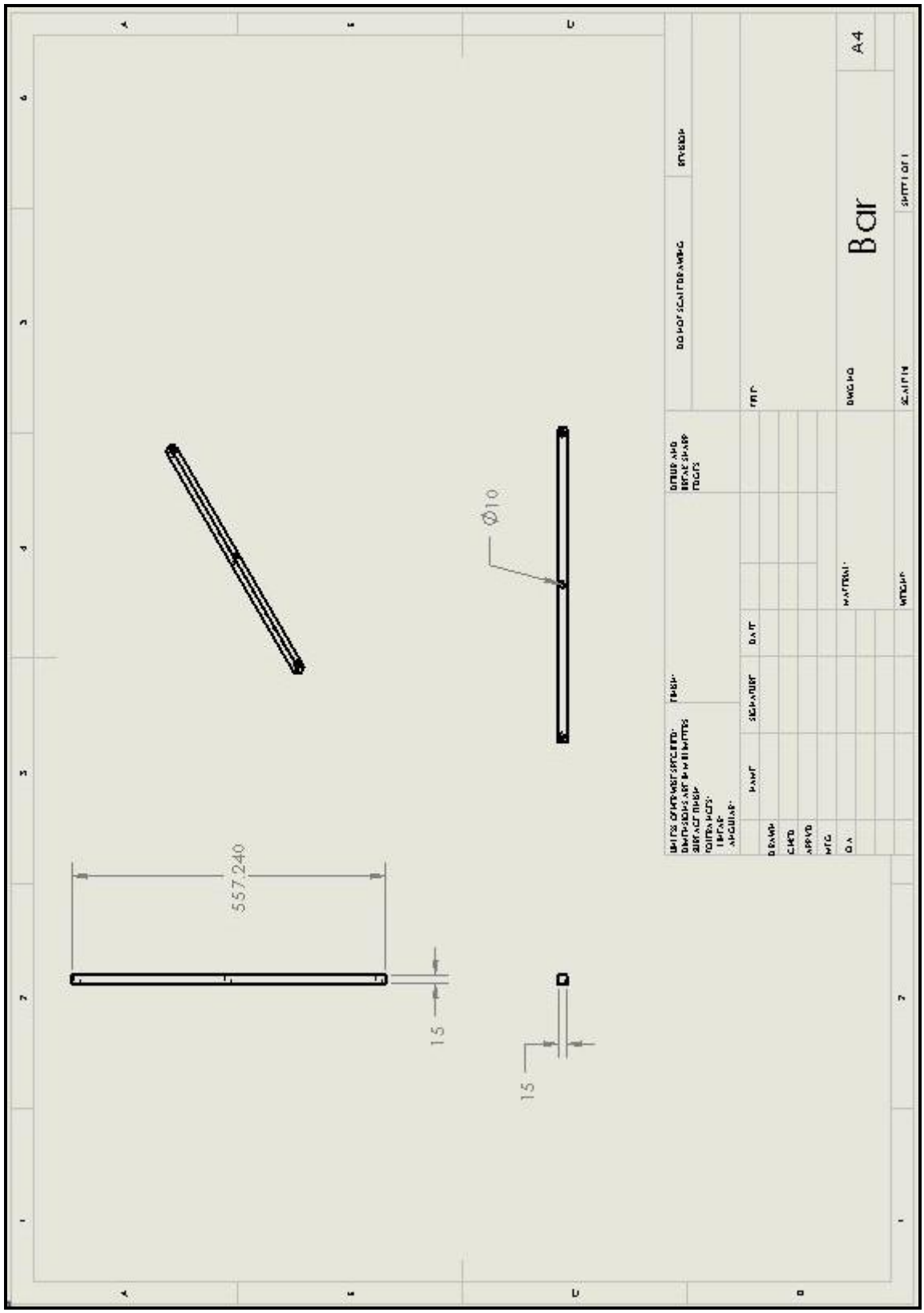

Seat
A4
530
440
30
40
5

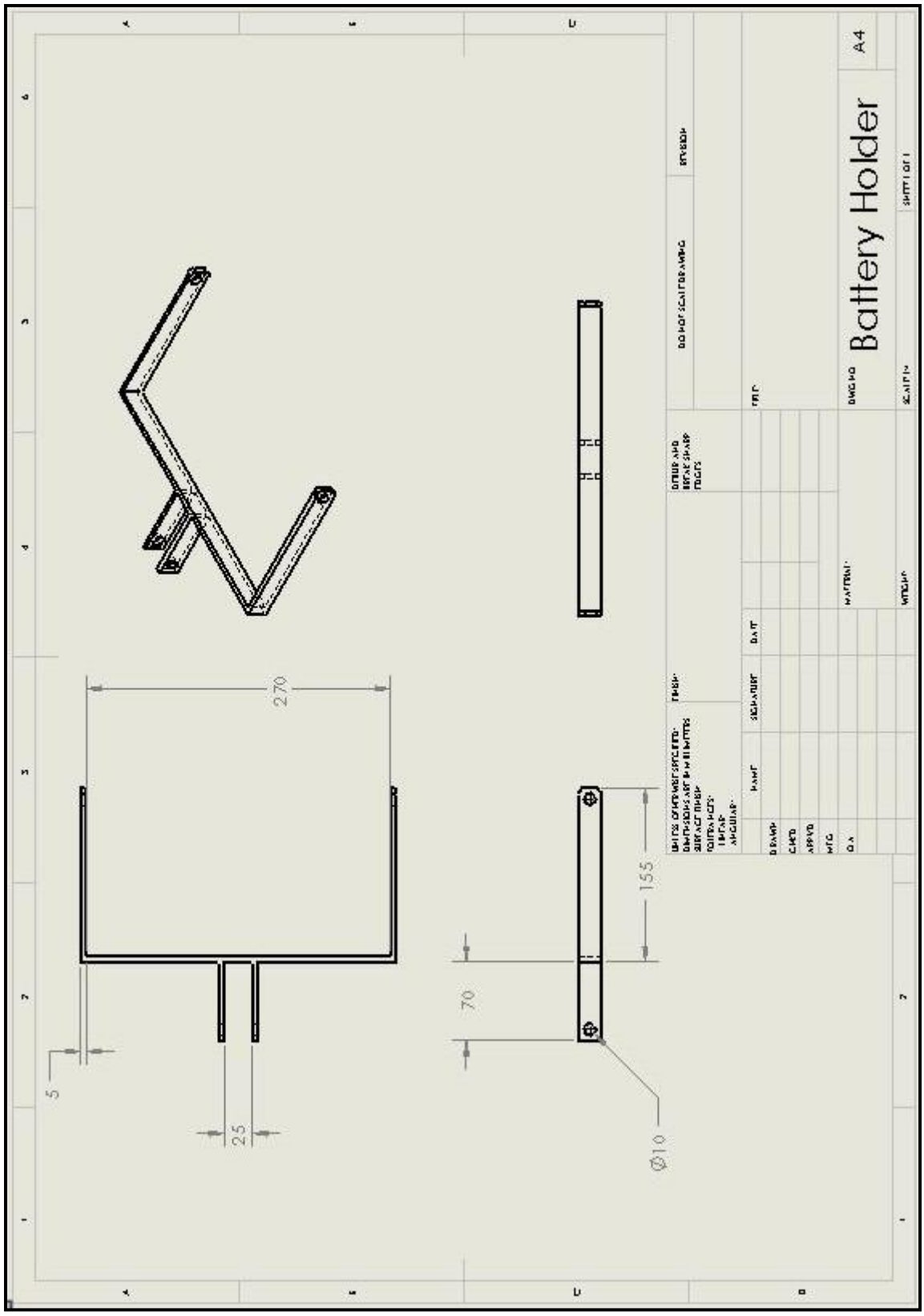

Bearing
A4
5
Ø27
Ø20

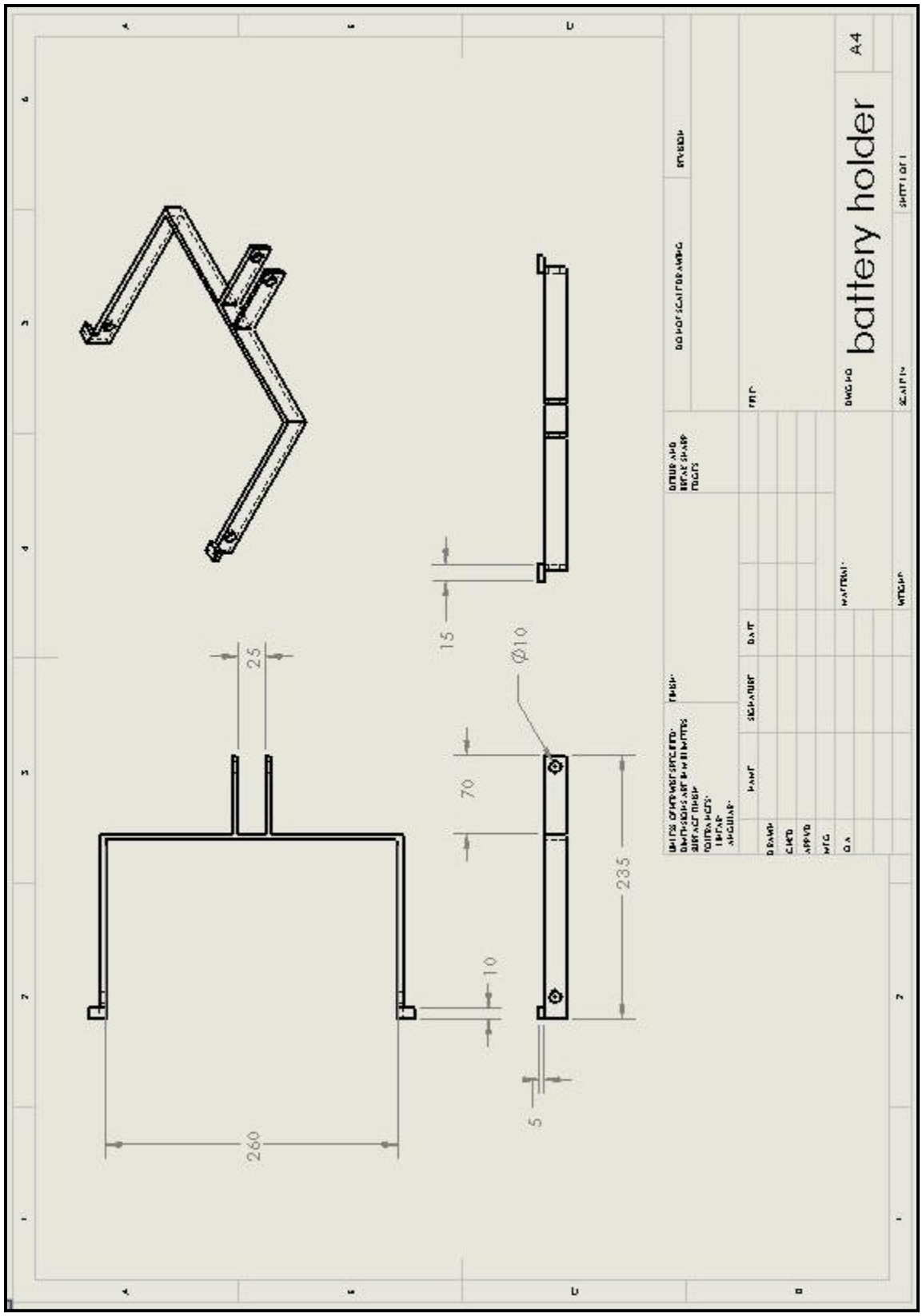

Hollow rod
A4
30
ϕ22
ϕ20

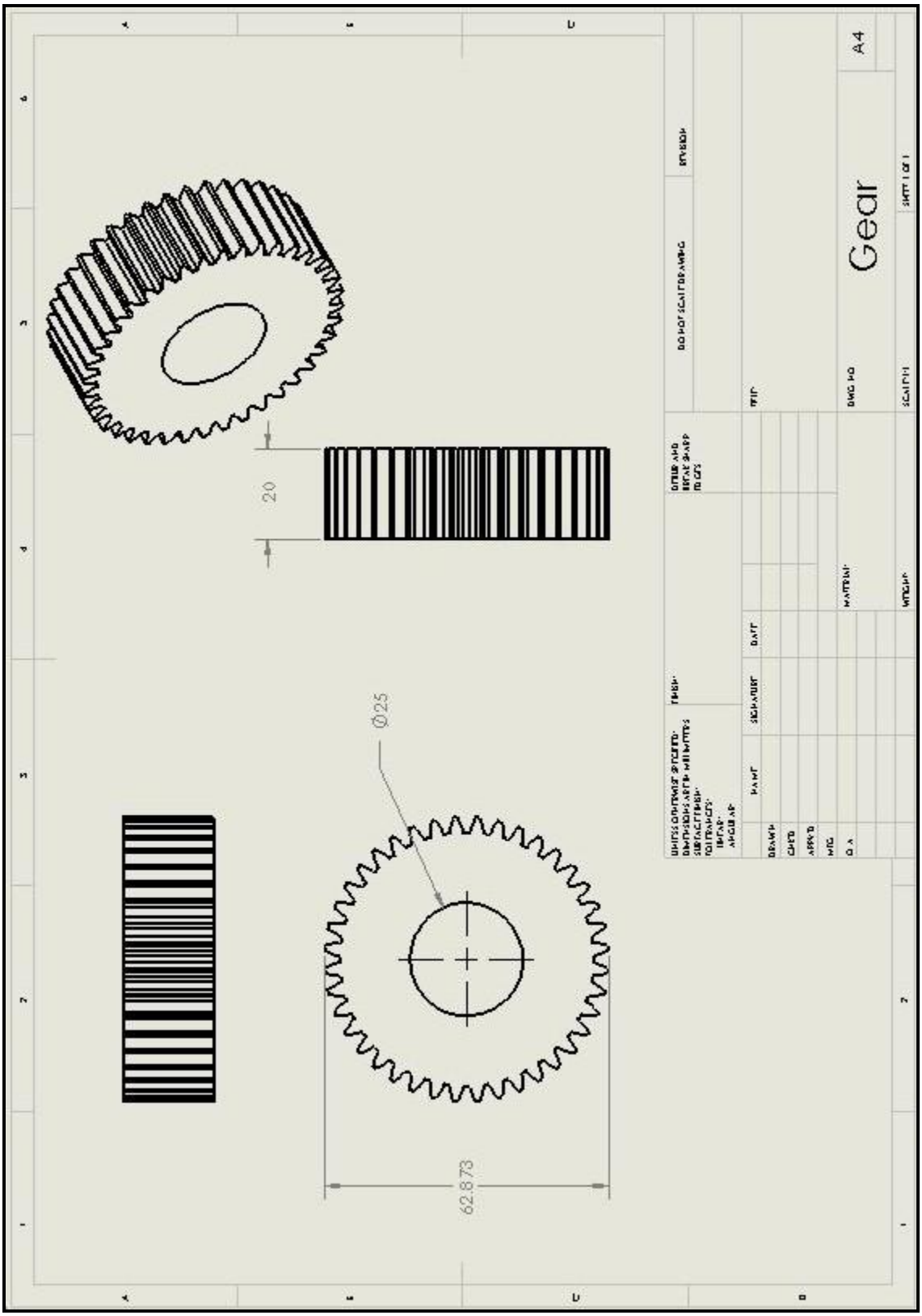

7
Ø37
Ø25
Bearing
A4

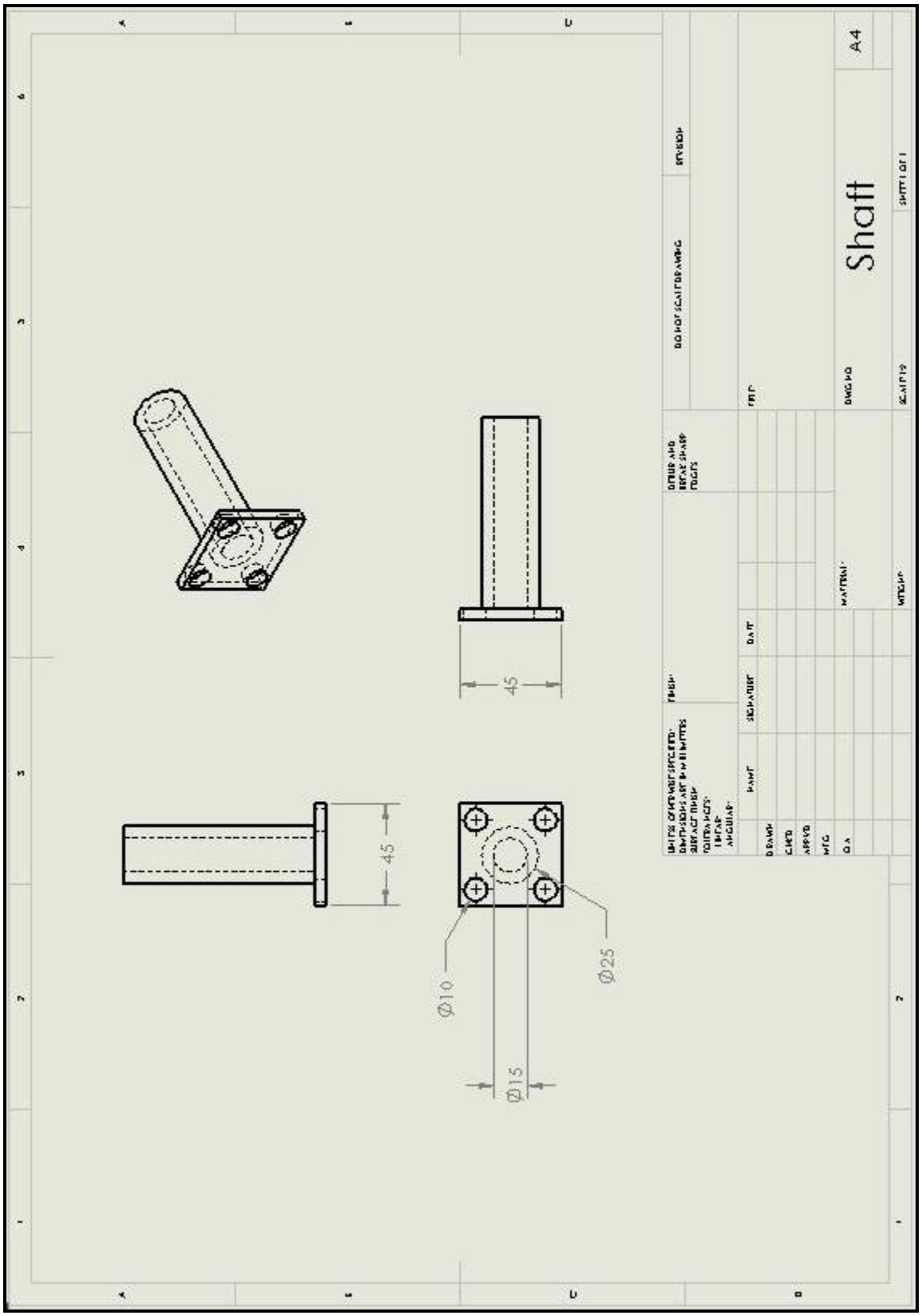

17
3
30
440
30
30
Bar
A4

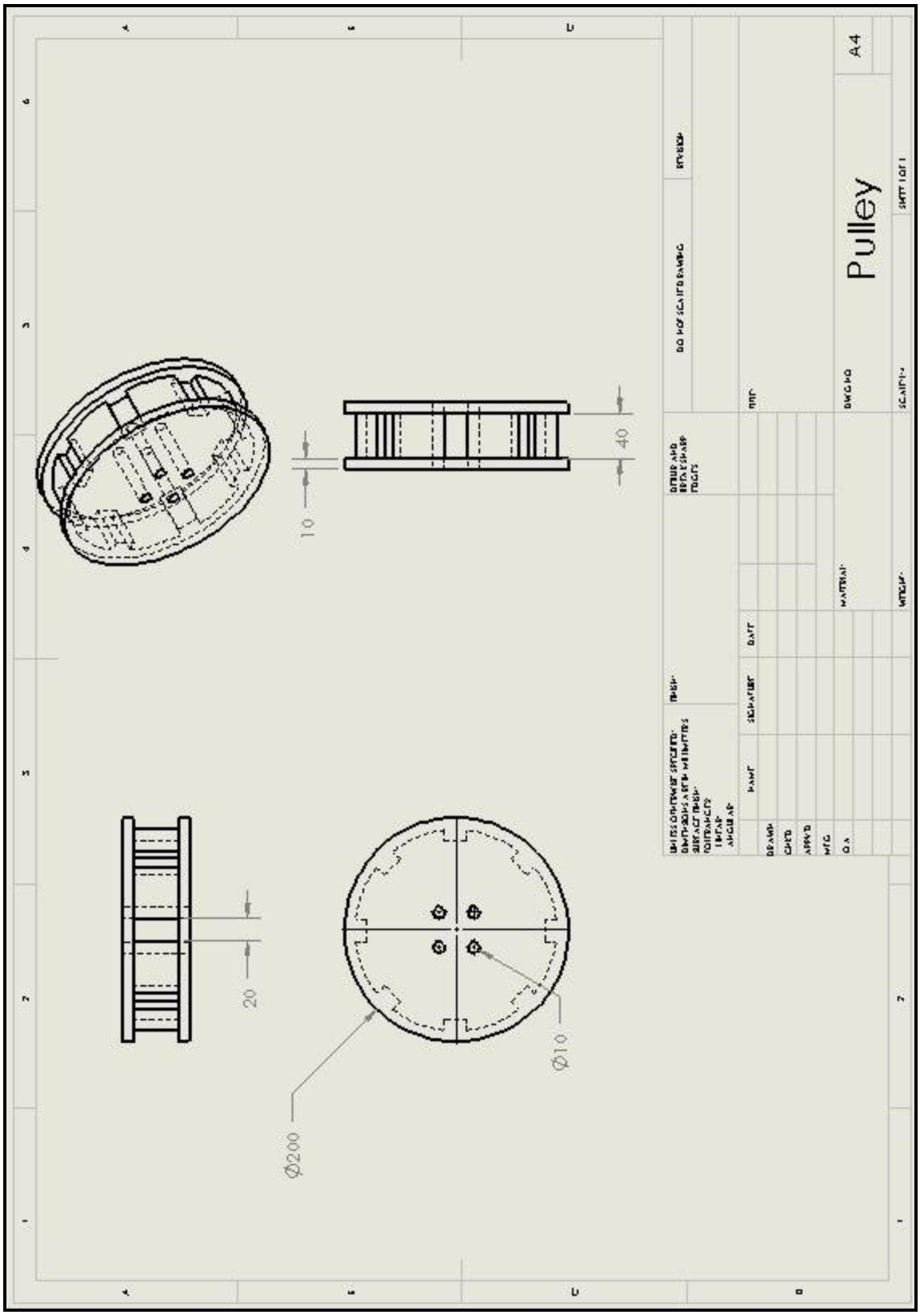

557.240
15
15
Ø10
Bar
A4

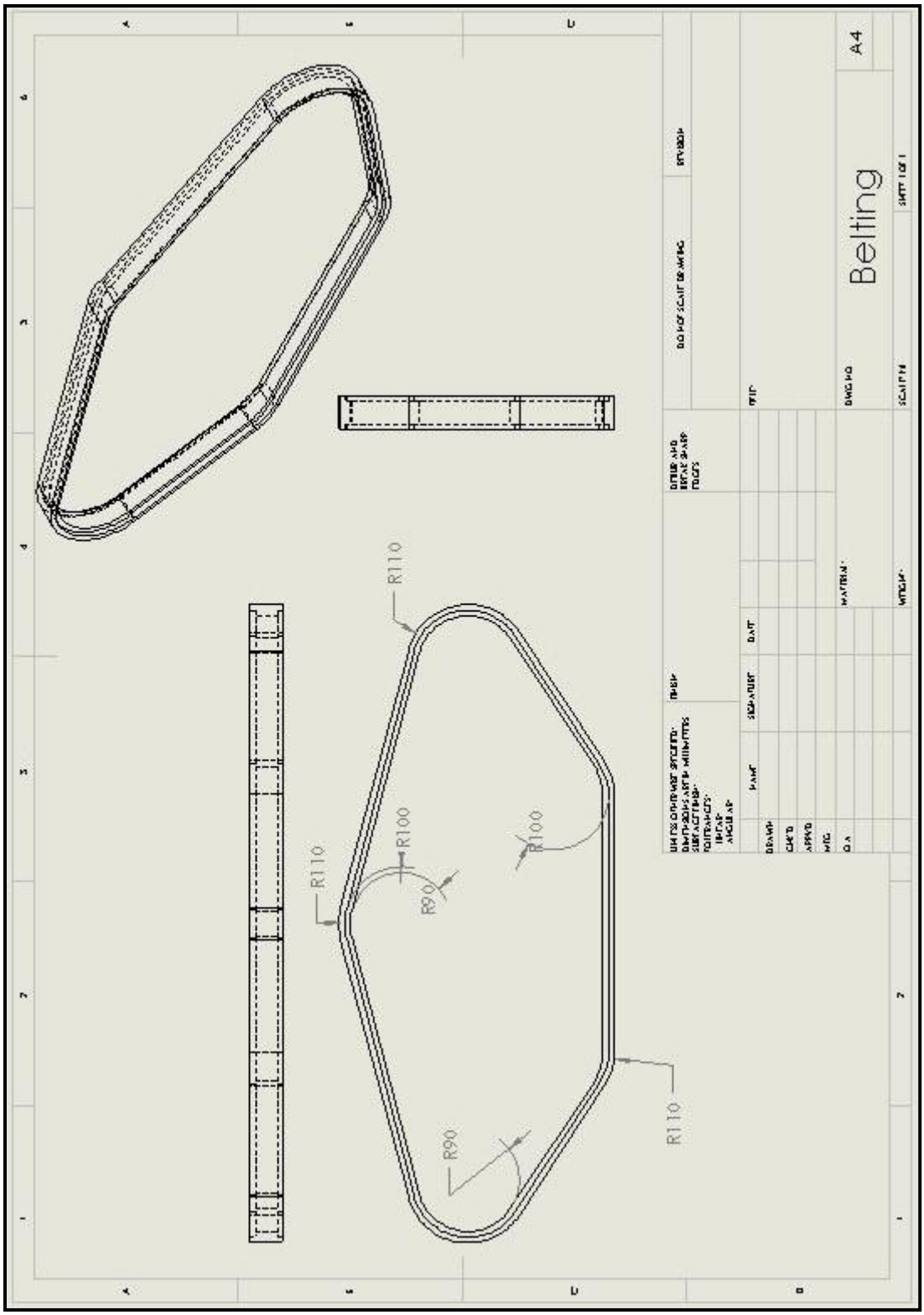

Battery Holder
A4
270
5
25
155
70
Ø10

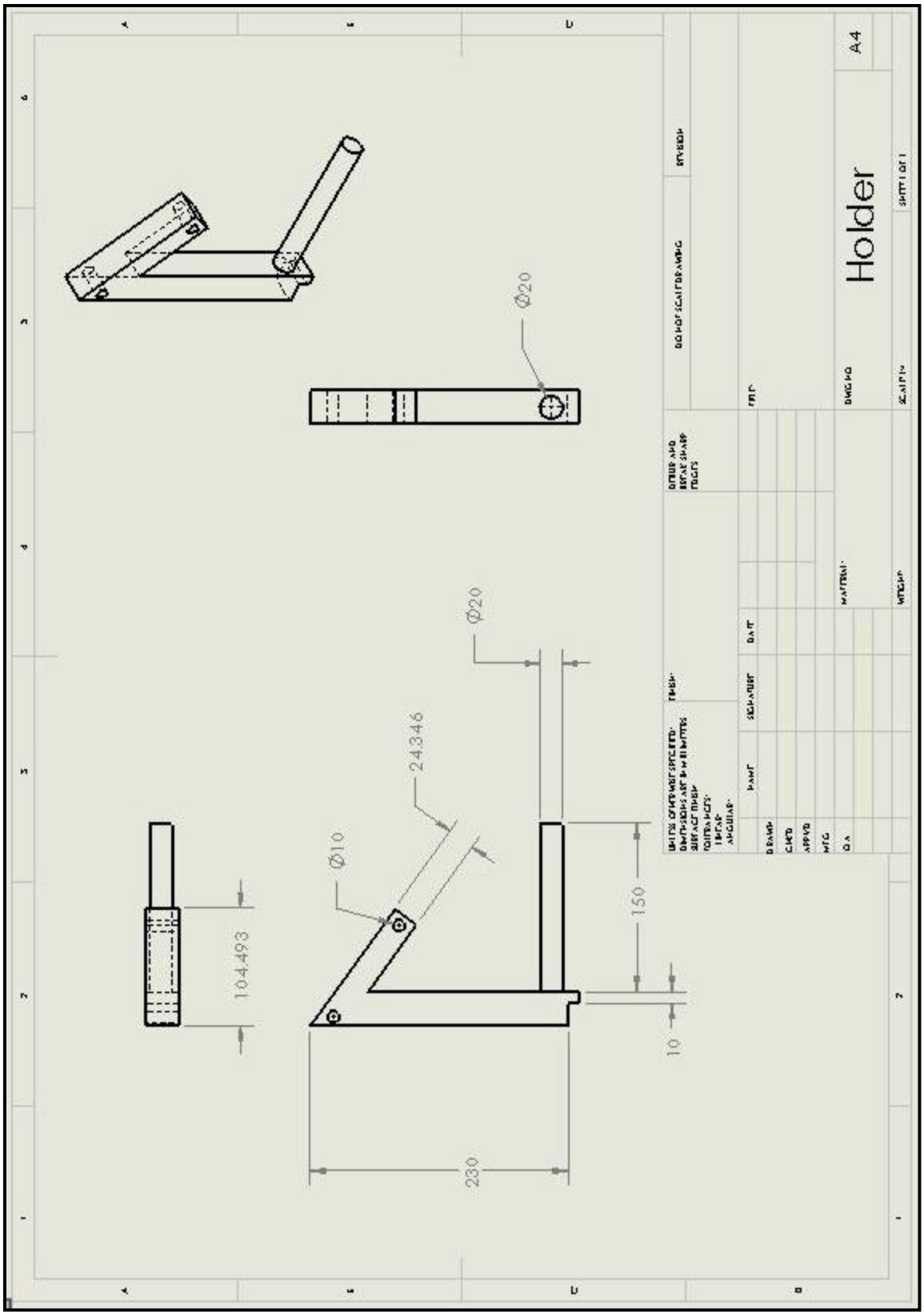

battery holder
A4
25
260
10
70
Ø10
235
5
15

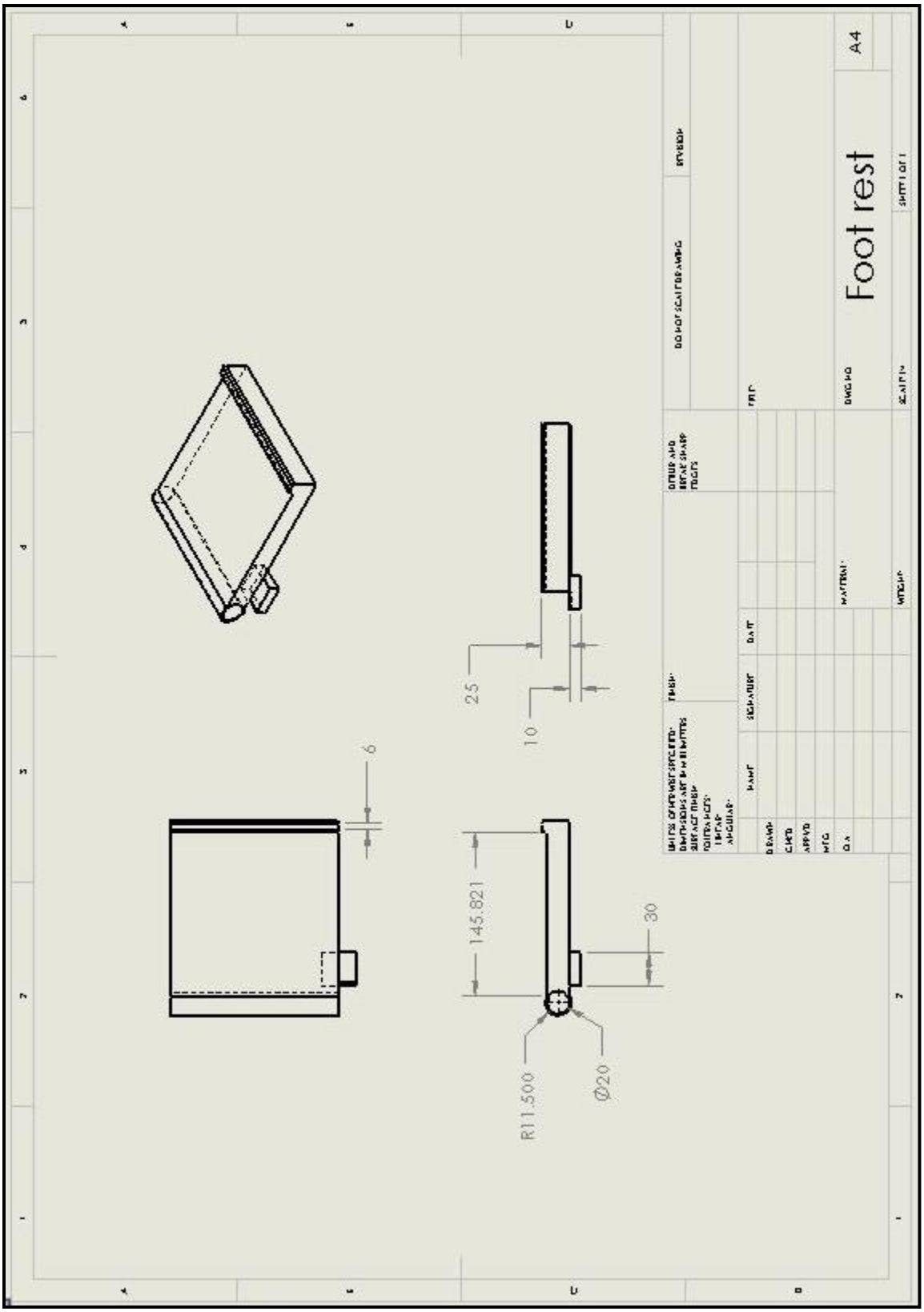

20
Ø25
62.83
Gear
A4


Shaft
A4
45
45
Ø10
Ø15
Ø25


Pulley
A4
10
40
20
Ø200
Ø10


R110
R100
R90
R100
R110
R90
R110
Belting
A4


Holder
A4
Ø20
Ø20
Ø10
24.346
104.493
150
10
230


Foot rest
A4
6
25
10
145.821
30
R11.500
Ø20

APPENDICES C

FOLD AND EXPLODE VIEW