جامعة الأمير محمد بن فهد
PRINCE MOHAMMAD BIN FAHD UNIVERSITY

College of Engineering

Department of Mechanical Engineering

Fall 2016-17

Design Project Report

Project Title

An Electrical Foldable Wheelchair

Team Members

	Student Name	Student ID
1	Ahmed Al-Saleh	201100756
2	Fahad Al-Rabiah	201002255
3	Fahad Al-Qahtani	201300006
4	Adnan BoKhamseen	201102941
5	Mohammed Al-Tawabini	201101394

Project Advisors:

Advisor Name: Dr. Mohammed Asaad

Co-Advisor Name: Dr. Nader Sawalhi

ACRONYMNS

ISO	International Organization for Standardization
V	Speed
σ	Stress applied on elements
F	Force
D	Distance
T	Time
Avg	Average
Xi	Sample value
ADA	American Disability Act

Table of Content

List of Figures

1 Introduction

People with disabilities usually face many problems when it comes to everyday life. Especially in the field of transportation, disabled people and their family members often have so many difficulties as they try to adapt with even the simplest of tasks. This is why we decided to focus our efforts in the purpose of designing and manufacturing a wheelchair that will make transportation simpler for people with disabilities as it could be folded into a size that is as small as possible and easily movable using its wheels.

1.1 Project Definition

Any kind of disability in humans, specifically mobility, visual, hearing impairment and cognitive disabilities are very depressing for the individual and the people surrounding him. The goal during this senior design project is to put a humble effort to make a change in the life of mobility disabled people. Americans with disabilities Act (ADA) was added to the law on July 26, 1990. According to this legislation no discrimination shall be observed with the disabled person in employment, state and local government, transportation, public services, public accommodation and telecommunications (for hearing impaired). By having this law approved, it’s time to move forwards with new clinical and rehabilitation technologies to provide disabled people with a near perfect life.

1.2 Project Objectives

The key objectives of this project are as follows:

- Making an Electrically powered Wheelchair.
- The Wheelchair is foldable.
- Cater children, Amputees and elderly.
- Robust control over the motion on steeps and slopes.
- Selection of drives and battery to allow the chair to move for the longest period possible without the need for recharging.

The team will make the design as simple as possible, this way the design will be relatively cheap and easy to manufacture. Thus, holding great commercial potential and a great opportunity of mass production.

1.3 Project Specification

There are many design guidelines for designing mobility assistive equipment in general and wheelchairs specifically. ISO 7176-1 to 7176-30 are specific guidelines for designing wheelchairs. Despite this, ADA sustains its own standards specifically documented for the needs of American people. ADA defines a wheelchair as “a manually-operated or power-driven device designed primarily for use by an individual with a mobility disability for the main purpose of indoor or of both indoor and outdoor locomotion. The wheelchair design must abide by the following functional requirements other than auxiliaries like power driven, stair climbing etc.

Seat: The seat must be stable and must be able to easily accommodate the external clothing. Balancing is the key because an imbalance and an unstable seat will cause asymmetry in the posture which leads to certain Traumas.

Maneuverability: Prime maneuverability is indoors. The wheelchair can be maneuvered through doors and working areas of the house. Moreover it is important that wheelchair must pass through the doorways, hallways, can make turns into rooms, can be easily reversed in toilets and restrooms etc.

Stability: with high level or double amputations has the weight deficiency in the front of the wheelchair which causes shift in the center of gravity. Wheelchair design must cater this issue and provide ultimate stability for different C.O.Gs.

Transportation of the Wheelchair: After using it during travel breaks the wheelchair must be designed in a way that allows it to be transported easily by the attendant. Now-a-days most of the manual wheelchairs are foldable but in the case of powered wheelchairs, batteries have to be removed before folding.

Ease of Assistance: Wheelchairs must be designed keeping in mind that any assistant shall not bare any discomfort.

1.4 Product Architecture and Components

In this concept, the team chose a simple design for a conventional wheelchair using Rack and Pinion steering Mechanism with single caster front wheels and double caster rear wheels.

1) Back rest.
2) Arm rest.
3) Seat.
4) Footrest.
5) Rack and Pinion for steering.
6) Front wheels.
7) Rear Wheels (Double caster).

1.5 Applications

•The electric wheelchair allows the disabled person to be self-dependent and removes the need for another person to help the user.

•Being foldable allows the wheelchair to be stored in relatively small spaces without the need for a large area for storage; even a relatively small scooter requires a full functioning garage to be stored.

•Being easily folded to such a small size removes the need for a long time to board or get off planes, trains and general public transportation.

2 Literature Review

2.1 Project background

The earliest records of wheeled barrows being used to transport disabled people date back to the 5th century BCE, but back then it was a barrow used for human beings and heavy objects alike. It wasn't until 525 CE that images of wheeled chairs made specifically to carry humans started to show in Chinese art. The German Renaissance also has records of using this technology but only in individual cases. In 1760, the Bath Chair was invented and produced commercially, the design is a three wheeled chair used by disabled people, this design was not very successful as it was big and needed a huge space for storage, It wasn't until 1993 that Harry Jennings and Herbert Everest who are both mechanical engineers, invented the first lightweight, steel, collapsible wheelchair. They saw the business potential of the idea and started mass production. Their "X-brace" design is still in common use up until today. In 1953, George Klein invented the electric powered wheelchair to assist injured veterans after WW2. From that time until now the basic idea of wheelchairs has developed dramatically from electric powered wheelchairs to electric scooters to full assistive units but one problem remains a great obstacle in the face of greater development in the field. This problem is that these units are large, heavy and very difficult to manipulate and store. Based on this issue, our team has decided to work on the design and manufacture of a wheelchair that is electric powered thus allowing the disabled person to use the wheelchair without the need of help from other people, and is also foldable in a matter that allows it to be stored in small areas and easily moved into and out of public and private transportation.

Figure 2.1 Old wheelchair

2.2 Previous Work

The heavy-duty power wheelchair

The heavy-duty power wheelchairs are designed to overcome almost any type of obstacles. They have a weight capacity of almost 205 Kg. They come equipped with powerful dual motors. The design of the chair is very comfortable coming with adjustable backrest, and armrest to provide full comfort. Mechanically these chairs have an extreme low center of gravity and come equipped with full suspension on all wheels. For a street ride it offers LED headlights and turn signals. However; they come in a very high price of around 8000$. Model shown in figure 2.2

Figure 2.1 the heavy-duty power wheelchair

Ultra-light Travel Chair

The ultra-light travel chair weighs only 8.1 kg. It's folding mechanism and light weight are very convenient for travelers. It is made of reinforced aircraft-grade aluminum frame that offers comfort and security. It also comes in a very good price of 350$. However; it is not electrically powered and it will not in passenger airplane cabinet. Model shown in figure 2.2.

Figure 2.2 Ultra-light Travel Chair

2.3 Comparative Study

BYU Motorized Wheelchair

Five BYU Mechanical Engineering students designed, manufactured constructed a low price, lightweight motorized wheelchair for children. It is made with a PVC frame enough to handle 50 pounds or about a 6 years old child. The wheelchair is controlled with a joystick mounted on the armrest like any electric wheelchair. It was produced for a total price of 495$ making it the world's least expensive motorized wheelchair.

Figure 2.3 BYU Wheelchair

Compared to our project we are following the same idea. However; our goal is to make the lightest and smallest wheelchair when folded that is able to fit in an airplane passenger cabinet. Instead of using a PVC frame, we are most likely going to use aluminum and the structure should be able to handle up to 264 pounds in weight. The wheelchair we are designing is not only made for children, but for everyone who's in need and the price should be very affordable.

3 System Design

3.1 Design Requirements, Constraints and Specifications

Based on these criteria the team decided that Concept III was best fit to be chosen as the final design as it was designed as a modification to overcome the obstacles that the other concepts were facing. This concept is the most stable one; using the back supporters this design can easily serve users with any kind of disability while maintaining a stable form. In regards to the folding process, this design is considered superior to the other concepts as the central plate plays a main role in making the folding process faster and easier. Furthermore, in means of fabrication this design is better than other concepts as it uses more effective parts focusing on central parts that perform multiple roles, the front wheels frame holds the battery and the front wheels and acts as leg support.

Concept I:

In this concept, the team chose a simple design for a conventional wheelchair using Rack and Pinion steering Mechanism with single caster front wheels and double caster rear wheels.

The main parts of the assembled concept are as follows (as numbered on the figure):

1) Back rest.
2) Arm rest.
3) Seat.
4) Footrest.
5) Rack and Pinion for steering.
6) Front wheels.
7) Rear Wheels (Double caster).

After discussing this design we concluded the following:

Strengths:

- Foldable
- Double Caster Wheels for better traction to avoid slippage and better control.
- Rack and Pinion mechanism for steering, one motor required for steering
- Relatively smaller front wheels for smooth movement.
- Two Separate motors for each rear wheel.

Weaknesses:

- Rack and Pinion mechanism hinders the foot rest while folding.
- Chance of slippage in Rack and Pinion mechanism.
- Double casters require more power and draws more current from the battery results in early discharge of the battery thus, reducing battery life and the need for a larger battery if we wish to overcome this obstacle.
- Double Casters increase substantial weight.

Concept II:

The main problem with Concept I was its heavy weight. Moreover, the problem between Rack and Pinion steering mechanism and the folding process of the foot rest rendered the concept ineffective. In Design Concept II the team tried to address these problems and solve them using single caster rear wheels (lighter) and using a single motor for the steering of each front wheel. The following figure shows the assembled concept.

Parts:

1) Back rest.
2) Arm rest.
3) Seat.
4) Foot rest (folded position).
5) Single motor for each front wheel for steering.
6) Front wheels (with spokes)
7) Rear wheels (single caster)

Strengths:

- Easy Folding Mechanism.
- Lighter weight compared to previous one
- Single but slightly wide rear wheels to provide sufficient traction while consuming less power.
- The use of two single smaller motors for steering rather than one big motor result in lighter weight and power efficiency.
- Very less chance of slippage in steering.
- Footrest can be easily extended and retracted.

Weaknesses:

- Difficult Braking Mechanism
- Even though the single caster rear wheels are lighter and consume less power, they are slightly less stable than the double caster wheeled system.
- Less Efficient Casters.

Concept III:

After finishing the design of Concept II and discussing it m the team reached the conclusion that even though Concept II is better than concept I it can still be modified and optimized to overcome the certain weaknesses. This led the team to reach and design Concept III.

Concept III is similar to Concept II except for a few modifications that include:

- The addition of two supports on the lower back of the wheel chair (between the two rear wheels), this supports prevent the wheelchair from overturning to the back in case the user has one or both legs amputated, which results in a shift in the center of the gravity.
- The team changed the concept of the front wheels frame and the leg support into one frame that is linked to a central plate and will be responsible for holding the front wheels and providing the leg support, in addition, the battery will also be mounted to this frame.
- The team linked the newly designed front wheel frame to the seat using a supporting member that will support the seat and the loads that it carries.
- To facilitate the process of moving the folded wheelchair, we added a handle to the top of the back support and an additional set of wheels to the sides of the battery. When the chair is folded the additional wheels, which are now located on the lower backside of the wheelchair will be used to drag the folded chair easily.
- The team used a central plate that is linked to the back, the seat, the front wheels frame and the back wheels. This plate will facilitate the folding process making it easier and faster than the previous designs.

The following is a simplified figure of Concept III. The main concept along with its parts is further discussed in the next chapter.

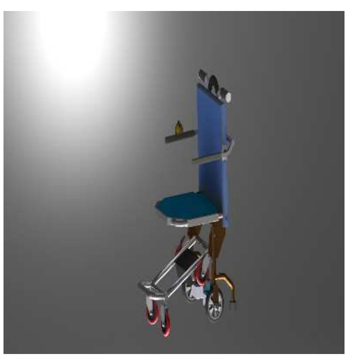


Figure 3.3 Design concept 3

Project Specification defines the features of the solution proposed by project executers. Sometimes the word specifications may refer to the data sheet. The data sheet has all the required technical information about the design, material used and production process. However, specifications are also related to the prevailing standards which have been developed by several organizations like International Organization for Standardization (ISO). Keeping in mind the definition of project specification, specifications for this particular project are:

1-Wheelchair is foldable and can fit in the size of 22" length x 14" width x 9" height so that it can fit easily in a backpack.

2-All wheels of the wheelchair will not exceed the diameter of 6 inches,

3-If the conventional wheels will be used in this design then it will restrict the foldable size requirement of the Project.

4-In unfolded condition, the chair will take an ergonomic shape that will be comfortable to use.

5-Ratchet Mechanism will be used on both of the rear wheels of the wheel chair for braking purposes on steep surfaces and slopes.

6-Both the rear wheels of the wheel chair will be powered by ABB asynchronous motor, mostly used in Segway, with the wattage of 750 W.

7-Lithium Iron Phosphate battery of 24V and 30AH will be used. The battery has weighs 7.5 pounds and its dimensions are 10.8 x 4.1 x 6 inches.

8-This battery works for 90 minutes and is fully charged in 25 minutes.

9-To Turn the wheel chair, the front wheels will be turned with the help of motors and the turn maneuver will be controlled by the speed of each wheel that will be manipulated by the hand movement of the patient.

All the power and electronic equipment that have been chosen are in compliance with the dimensions of the folded wheel chair as mentioned in the functional requirements of the project.

3.2 Selection Criteria:

The final design must comply with standard regulations (ISO, ADA) and with the specifications that the team has set. This design should be easily folded into the previously discussed size, it should be stable and easy to manipulate and maneuver. Furthermore, this design should perform more smoothly while keeping power consumption as minimum as possible.

3.3 Final Selection:

Based on these criteria the team decided that Concept III was best fit to be chosen as the final design as it was designed as a modification to overcome the obstacles that the other concepts were facing.

This concept is the most stable one; using the back supporters this design can easily serve users with any kind of disability while maintaining a stable form. In regards to the folding process, this design is considered superior to the other concepts as the central plate plays a main role in making the folding process faster and easier.

Furthermore, in means of fabrication this design is better than other concepts as it uses more effective parts focusing on central parts that perform multiple roles, the front wheels frame holds the battery and the front wheels and acts as leg support.

The final design is detailed in a thorough form in (Appendix A, Fig (5)).

An Exploded view of the final design showing every member and part used is also available in (Appendix A, Fig (6)).

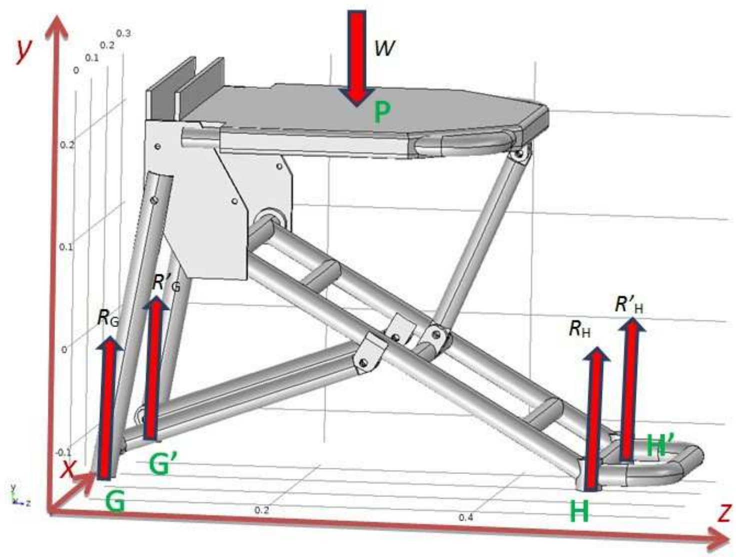
Computer generated images showing the final design that the team chose for the wheelchair in both folded and unfolded positions. These images are available in (Appendix A)

3.4 Analysis Of The final Design:

The team ran a computer analysis for the structure of the final design using computer software, making sure that this design is safe and secure as a whole and that each member is also within the right conditions to perform safely.

The analysis is discussed as follows:

1.2 External Equilibrium:



The following forces are acting on the whole structure: the load *W* at top which is the sum of weights including that of the user and self-weight, and the reactions from below at points G and H: ,, and . Due to the symmetry (w.r.t. the vertical plane *yz*), and . On points G and G' also horizontal reactions could be applied, but they are clearly null, since there are no horizontal loads.

This equilibrium is detailed in (Appendix A, Fig (10)).

The equilibrium of forces and torques as shown in equations 1 & 2:

Eq.

Eq.

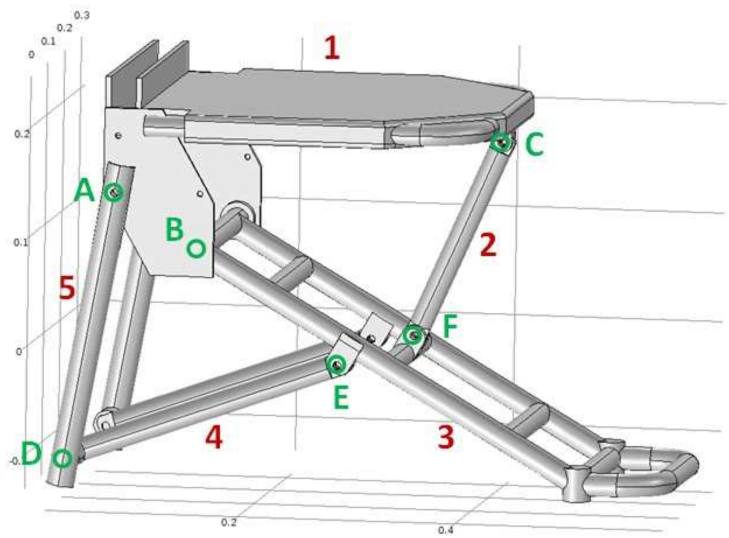
Where in, in and in.

Solution: **lbf,   lbf** .

Apart from the load and the reactions, the structure has internal forces, which we compute next.

1.2 Internal Equilibrium:

The main members of the structure are shown in the following figure, which is also available in (Appendix A, and their positions and coordinates are shown in (Appendix B)).



MEMBER #2

The piece is shown in (Appendix A, Fig (12))

Unit vector for direction from F to C:

MEMBER #4

The piece is shown in (Appendix A, Fig (13))

Unit vector for direction from D to E:

MEMBER #5

The piece is shown in (Appendix A, Fig (14))

From the equilibrium conditions:

We solve the internal forces acting on nodes, giving the equations (vectors are written in format [z-component, y-component]):

Where means torque of force w.r.t. Point .

Solution: **lbf,** **lbf,** **lbf** .

MEMBER #3

The piece is shown in (Appendix A, Fig (15))

From the equilibrium conditions:

We solve the internal forces acting on nodes, giving the equations:

Solution: **lbf,** **lbf,** **lbf** .

MEMBER #1

The piece is shown in (Appendix A, Fig (46))

From the equilibrium conditions:

We check that the previous solutions match.

There is no need to analyze the rest of the pieces (#2 and #4), as all forces have been calculated.

3.5 Fabrication

The fabrication process is one of the main and most important features of the project as it determines how easily the design is manufactured and how effective it is for the purpose of mass production.

The fabrication process was conducted as follows:

Material Specification

Material specification for this product has been in consideration since the beginning. Actual material specifications will be finalized after running stress analysis on the wheelchair. ANSYS will be used for performing structural analysis. The main material that was considered by the team was Aluminum, as this material is very light in weight. Refer to Appendix A, Figure (31).

Estimated Precision

Precision and mentioning required tolerances in the fabrication phase is essential for successful completion of the project. Geometric Tolerances and Dimensioning are basically the symbolic way of communicating required accuracy and precision. There are several standards available worldwide that describe the symbols and define the rules used in GD&T. One such standard is American Society of Mechanical Engineers (ASME) Y14.5-2009. For the said project we will strictly follow ASME Y14.5 for dimensioning and tolerance.

The Y14.5 standard has the advantage of providing a fairly complete set of standards for GD&T in one document. The ISO standards, in comparison, typically only address a single topic at a time. There are separate standards that provide the details for each of the major symbols and topics below (e.g. position, flatness, profile, etc.).

Methods:

The following methods were used in the fabrication process:

1. Manual Cutting:

Square tubes and pipes were cut to the required length using manual hacksaw for easy availability and scalability.

2. Machining:

CNC lathe and a Milling machine were used for the bore housing of plates and obtaining circular profile for the Frame for hand. For details please see routing sheets of mentioned parts.

3. Bending:

In the fabrication of wheelchair both pipe and sheet bending machines were used.

4. Drilling:

A powered drill machine was used for drilling holes in several parts of the wheel chair. For drilling detail please consult to the routing sheets.

5. Welding:

Electric arc welding was used for fabrication of different parts such as seat, back etc. due to ease of operation and availability.

6. Grinding:

A powered Hand Grinder was used for grinding sharp edges, welding beads and general smoothness of the surface.

7, Painting.

Parts Joining Requirements

It is obvious from our design that part fabrication is very simple. There are three types of profiles in our design: square tubes, pipes and sheets. As mentioned in the routing sheet of each part that cutting, drilling and welding were used for the part and subassembly fabrication. However fastening will be observed for joining of parts to form the complete assembly of the wheelchair.

Fabrication Process:

The team followed a certain procedure while fabricating the prototype of the final design. This procedure was conducted as follows:

1) Machine shop was fabricated as an individual part.
2) The team obtained all required parts that were needed from external sources.
3) After having all the parts ready for assembly, the team then assembled the parts by means of welding or joining.

The fabrication of members is further detailed in the routing sheets that are available in (Appendix B). Drafts and Dimensioning views available in (Appendix A).

The following is a graphic preview of the bill of materials, which is also available in (Appendix B).

Modifications:

It should be noted that during the fabrication process, the team figured that some members needed modifications and that some parts needed to be added so that the wheelchair would better serve the required purpose. These modifications are:

- The team replaced the joints of the supporting member that supports the seat and links it to the front wheels frame with a rotating cylinder which moves along the front wheels frame making the folding process even easier.
- To reach the desired size for the folded wheelchair, the members that hold the rear wheels have to be placed next to the front wheels frame. To improve this process we used an additional member that is linked to the rear wheels member and a rotating cylinder that will move along the side of the front wheels frame.
- All controls of the wheelchair are conducted using one joystick. This joystick can be placed on the right handed of the armrest.

Actual images of the fabricated wheelchair are available in (Appendix C) these images include fabricated members of Aluminum and parts that were obtained from external sources.

4 Testing:

It is very important to make a test plan to make sure that all the parts of the wheelchair are working properly. According to the standards mentioned in a number of design guidelines for designing mobility assistive equipment in general and wheelchairs in specific. ISO 7176-1 to 7176-30 are specific guidelines for designing wheelchairs. Despite this, the ADA sustains its own standards specifically documented for the needs of American people.

4.1 Features to be tested:

The wheelchair efficiency test includes the test of Movement of the wheelchair in order to make sure it requires less or no human effort, testing the ability of the wheelchair to be folded to fit into a portable Back Pack and to test the dimensions of the wheelchair After folding, testing the breaking system while moving on steeps and slopes, testing the renewable power that drives the wheelchair and its ability to be charged, testing the Charging time in order to make sure it is at least three times shorter than discharging time, balance, maneuverability, circuits, connections and testing the stress applied on different parts such as the seat, wheels and several other components.

4.2 Testing Methodology

A testing facility for the electric circuit of the Wheelchair is available in (APPENDICE B).

1.1 Testing of Circuits:

In this step, all the Electrical part will be tested before installing it into the wheelchair.

1.2 Testing of Connections:

All the soldered and other electrical connections will be tested after the installation.

1.3 Testing of Motors:

Motors speed and torques will be tested on both dry run and loaded condition before installation

1.4 Testing of Battery

Battery was tested on dry run and loaded conditions from full charge to full discharge after installation.

Control System

1.1 Before Installation

After connecting all components on the controller, the control system was tested before installation for control strategies. This testing includes observing that each switch was signaling the correct movement before installing it on the wheelchair.

1.2 After Installation (maneuverability)

After completing the assembly of the wheelchair, maneuverability of the wheelchair was tested in both static and moving conditions. This testing includes the direction of the motion, braking and timing.

1.3 Dimensions:

The length, width, and height of the folded wheelchair were measured using a self-retracting tape measure.

1.4 Motor:

Driving the wheelchair for a certain distance with a relatively heavy load tested the motor, and then we measured the distance and divided it by the time needed to cross it to measure the speed. The result was then compared with the required speed to provide a comfortable experience for the user and to make sure that the motor complies with the specifications that the manufacturer has provided.

1.5 Breaking system:

Testing the stopping process of the wheelchair from maximum speed to zero without disturbing the comfort of the user or putting them in any kind of danger.

1.6 Power and Battery:

Measuring the time needed for a full charging process from zero to full battery and the time needed to empty the battery with continuous use.

1.7 Stress and Forces:

Applying the force that we need the wheelchair to endure according to maximum weight of user and calculating internal forces of members and stress by dividing the force by the area of the member and comparing the results with the allowed values according to the used material (Aluminum).

1.8 Circuits and Connections:

Testing the ductility of wires and checking that all the electronic parts are connected in the right manner.

4.3 Data Analysis:

Speed:

The speed of the wheelchair is the distance divided by the time needed to cross it according to the following equation:

[]

Stress:

The stress is the value of the force applied divided by the area of the member that is being analyzed according to the following law:

Results average:

The average is the sum of all the result values divided by the number of results.

This average must not exceed the allowed values.

As for test results, these can be found in (Appendix B)

5 Project Management

5.1 Project Plan

The schedule which the design and manufacture must follow was thoroughly studied and accurately measured and designed so that it would give an accurate view of the overall time needed for the manufacture of a single unit product. The detailed chart of the time schedule followed by the team in the design phase and to be followed in the manufacture phase is shown in Appendix B**.**

5.2 Team Members Contribution

Ahmad AlSaleh has the ability to communicate with people. Ahmad has the potential to discuss and listen to others' ideas even if they were wrong. He is the team leader. He is the one who arranges team meetings and discussions, as he has the time management skills.

Mohammad Altawabini has technical writing skills. His grammar and spelling are very good. He has the ability to communicate with others and listen to their opinions. Mohammad is the reports' editor as well, as he has good writing and grammar skills and is experienced in Microsoft word and excel.

Adnan Bokhamseen has Solidwork skills. He is very talented in Solidwork. He has the ability to work for hours enjoying what he is doing. He is a very helpful member in the team. Adnan is the Solidwork expert, he did the samples for every component, and his skills with Mechanics of solids and statics are very useful as our project depends basically on these two subjects.

Fahad Alqahtani and Fahad Alrabea have programming skills. They know how to manage their time by doing everything in advanced before the deadline. Fahad is the one who programs, analyses and does all of the calculations using his skills with Microsoft excel.

5.3 Project Execution Monitoring

Meetings with advisor were very helpful as he guided us through the whole project step by step. He reviewed all of our plans and progress. Any mistakes we had he provided full support and advice. Dr. Mohammad Alasad is our co-advisor with regards to him were able to finish the project on time without any delays.

Dr. Nader Sawalhi is our advisor who went through our reports and presentations providing full details on how to work and how to make plan. Our team with regards to his advice were able to make a full managed plan by our team leader Ahmad Alsaleh who was responsible for all meetings and listing all problems to be solved.

The team meetings were made three times a week, two times discussing and solving problems and the third meeting is in the workshop making the parts and assembling them. The team was very punctual no delays were made or excuses by team members. Whoever had an excuse was excused and some other team professionally covers his place.

5.4 Challenges and Decision Making

Our team was able to go through all of challenges together to solve the problems. Decision making was taken by voting. As the team had multiple choices we would evaluate each problem's solution and vote for the best.

As we were conducting our studies on the design, we found that some parts of the product were not in their optimum form. So we decided to modify some components in a way that they would reach optimum levels of comfort for the user and would better serve the main goal of the project, these modifications are briefly explained in the following points:

- The battery was placed behind the back of the wheel chair. But as a relatively heavy part, we thought that it might shift the center of gravity in a way that would cause the wheel chair to overturn, especially when the user has both legs amputated, so there is no weight that would act as counterweight against the weight of the battery.

  The new position for the battery would be under the chair, as this would make the chair more stable and will not affect the foldability of it.

- for further safety against overturn, two stocks were added behind the back wheels that would support the wheel chair in case it overturned and will stop it from falling on its back, thus adding more safety for the user and avoiding catastrophic accidents. These two stocks are also foldable so that they wouldn't take up any space when the chair is folded.

- Two small wheels were added on the sides of the battery under the seat. When the chair is folded, these small wheels would be positioned behind the rear

Wheels in a form that they would assist the front wheels in the movement of the chair.

- The rear wheels were equipped with two separate motors that are both connected to the control stick that would be manipulated by the user. This addition eliminates the need for a turning box and an axis for turning.

  The way this mechanism works is that when the user shifts the control stick to the right to turn the chair to the right, the left rear chair motor would gain a bit more speed compared to the right one, and so the chair would turn to the right and vise versa.We believe that this solution will be for the best of the project and would serve the overall main goal of our idea. That is if one motor is to be used, it would need a gear box and a turning box and an axis for it to perform the required actions, and the motor itself will have to be big and that will add an obstacle for foldability. However, these two small motors would perform the task with great efficiency as turning would now require less space (at one point if one of the rear chairs is standing still and the other is moving the chair would turn around a fixed axis with no need of big turning circles, thus adding more ease of movement for the user).

- When examining the dimensions of the parts we found that the front wheel frame (which also works as a support for the feet of the user) is too long for its purpose. This creates two problems, the first is that it would make the user uncomfortable as it would be far from the seat and the other is that it would add a considerable amount of length to the overall length of the product when it's folded which negatively affects the main goal of the project which is to create a foldable wheel chair that can easily fit in a back pack.

- Adding a carrying stick between the two sides of the hands frame which will make the chair easier to carry when it is folded.

- Adding the control stick that would allow the user to control the speed and movement of the wheel chair using one hand only.

These modifications are in Appendix C. While the chair before the modifications is shown in Appendix A.

5.5 Cost Approximation

Cost is considered to be one of the most important factors when determining the success of any given project. The overall cost is divided into a wide branch of expenditures, from materials to parts that are readily bought to the price of labor. If the overall cost of a project exceeds primary expectations, it might render the whole project useless as the final product might not be efficiently marketable.

The cost of raw materials that are used in the manufacture of parts was calculated based on market prices, keeping in mind that some materials are going to be directly bought from local markets while other materials will have to be specially ordered.

The following is a simplified preview of the cost of each part of the wheel chair:

- Back: between sheets, pipes, fabric, screws, nylon and other materials, the overall cost is 395 SR.
- Frame for hand: Square tubes, pipes and a special plastic frame. The overall cost is 125 SR
- Plate: Carbon fiber sheets and pipes. the overall cost is 140 SR.
- Seat: pipes, Nylon, sheets, liners and screws, the overall cost is 545 SR.
- Front wheel frame: steel pipes and screws. 120SR.
- Front wheel support: Carbon fiber sheet, pipes and screws. 60 SR

Other materials that will be bought directly or specially ordered include:

- Battery. 565SR.
- Battery charger. 95 SR.

- Servo motor. 450 SR.
- DC motor. 720SR.
- Gears. 525 SR.
- Transportation Cost: 1250 SR.

As for labor, it consisted of cutting, shaping, forming and installing following the methods that were discussed previously. Table (9) in Appendix B shows the estimated labor costs. The biggest part of the overall costs went to labor as many parts of the final product are going to be made in the workshop, which means we will need workers to conduct the required actions. The overall cost of the project is shown in Appendix B.

6 Project Analysis

6.1 Life-long Learning

The team earned many new technical and theoretical skills in which it includes:

Solidwork professional skill

Mechanics of solid solving skills

We learnt about batteries and motors

Automatic control skills were earned on programming the joystick and the chair

Microsoft and Presentation skills

Material selecting skills using ANSYS.

6.2 Impact of Engineering Solutions

People with disabilities usually face many problems when it comes to everyday life. Especially in the field of transportation, disabled people and their family members often have so many difficulties as they try to adapt with even the simplest of tasks. This is why we decided to focus our efforts in the purpose of designing and manufacturing a wheelchair that will make transportation simpler for people with disabilities as it could be folded into a size that is as small as possible and easily movable using its wheels. Our team's main goal is to make an electric foldable wheelchair that is easily put in a carry-on size bag and with a cost limit that insures that the final product is available for everyone. Our project is unique and new. Our team believed that our project would be helpful for people with disabilities, making disabled people more comfortable. That would be one of the important goals that our team is looking for. Each and every team member has worked very hard and gathered all information to make our project executable. The key objectives of this project are making an Electrically Powered Wheelchair

Foldable to the size of 22" length x 14" width x 9" height, Cater children, amputates and elderly, and Selection of Drives and battery to enhance battery time.

6.3 Contemporary Issues Addressed

People with disabilities in Saudi Arabia face problems with expensive wheelchairs and use common large wheelchairs. Airports in Saudi Arabia are very large and people with disabilities can use our wheelchair to move around easily plus it can be put with you in airplane passenger cabinet.

7 Conclusion

7.1 Conclusion

The team has worked on the idea of a conventional wheelchair and decided to improve it by making the wheelchair both electric powered and foldable to a small size. This idea could be revolutionary in the communities of disabled people as it provides an electric wheelchair, which helps disabled people with their basic everyday works without requiring a large area for storage as it can be folded to a very small size making it easily stored in a very small area. The final design was effective enough that it is easy to carry on inside a plane or drag and maneuver which makes it easier to use public transport or simply store in an ordinary closet.

The team also worked on making the final design simple enough that it would have great commercial potential, as it is cheap and easy to manufacture on large scales.

7.2 Future Recommendation

One of the main problems that the team faced since the beginning was the lack of financing and sponsorship, which forced us to self-finance the project. The team focused since the beginning on designing the wheelchair in a simple manner that allows for easy manufacture on a mass scale without the need for much experienced hands. Furthermore, our sponsor believe that the final design that submitted is going to be easy to produce and also cheap which makes it great for mass production systems. The idea of having such a useful wheelchair is going to be a great idea in community as the final design is effective and helpful and also easily folded into a small size with easy steps, our sponsor think that this product will be very popular and will have a wide base of customers.

8 Appendix

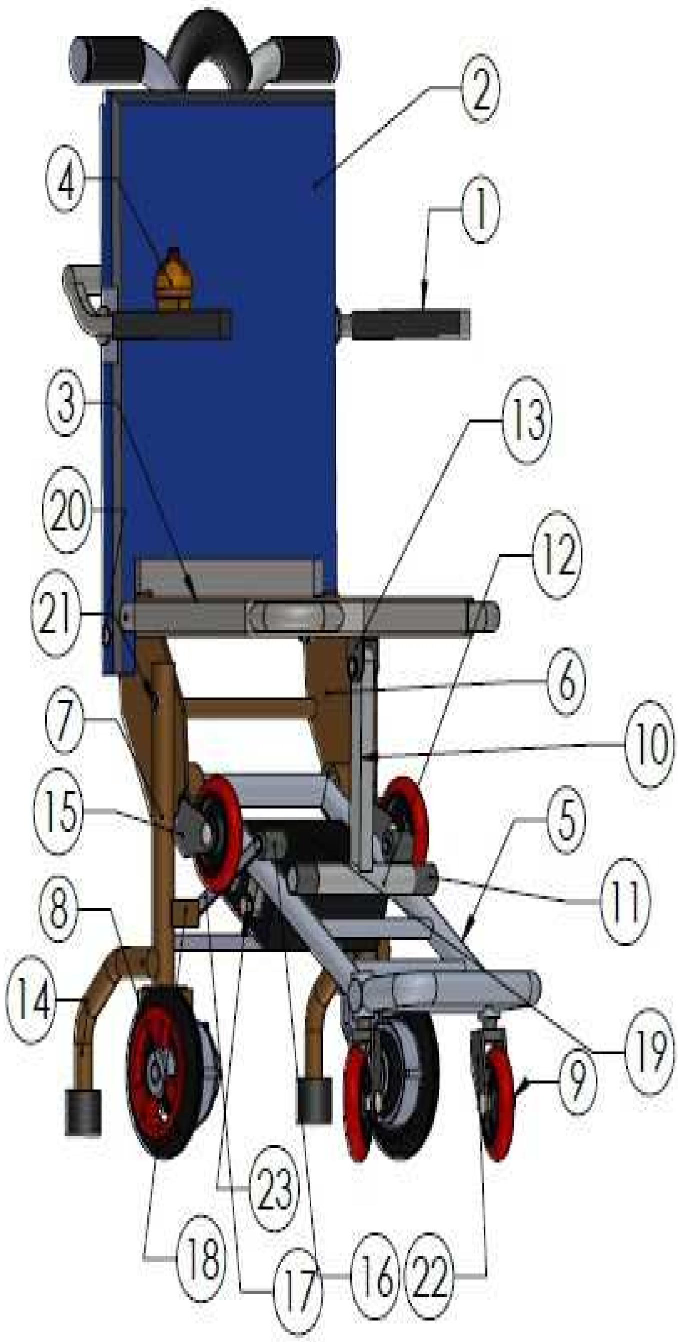
Appendix A: Design, Charts and Calculations

Figure Concept 1

Figure Concept 2

Figure Concept 3

Figure Concept 3



ITEM No.	NAME OF PART	NUMBER OF PART
1	Fram for hands	1
2	Back	1
3	Seat	1
4	Control arm	1
5	Fram front wheel	1
6	Plate	1
7	Front wheel support	2
8	Back wheel with motor	2
9	Front wheel	2
10	Frame front wheels supporter	1
11	Rotation cylinder	2
12	Rotation cylinder piece	1
13	Fixation link	1
14	Back support	2
15	Set wheel 3	2
16	Rotation cylinder 2	2
17	Link (leg , frame)	2
18	Fram front wheel link	2
19	Lithium battarey	1
20	DIN 1445- 8x50 St-N	2
21	0.3125-clevis pin	2
22	Set front wheel	2
23	Heavy hex flange screw, M8 x 1.25 x 12 - - 12N	4

Figure A detailed form of the Final Design showing all parts.

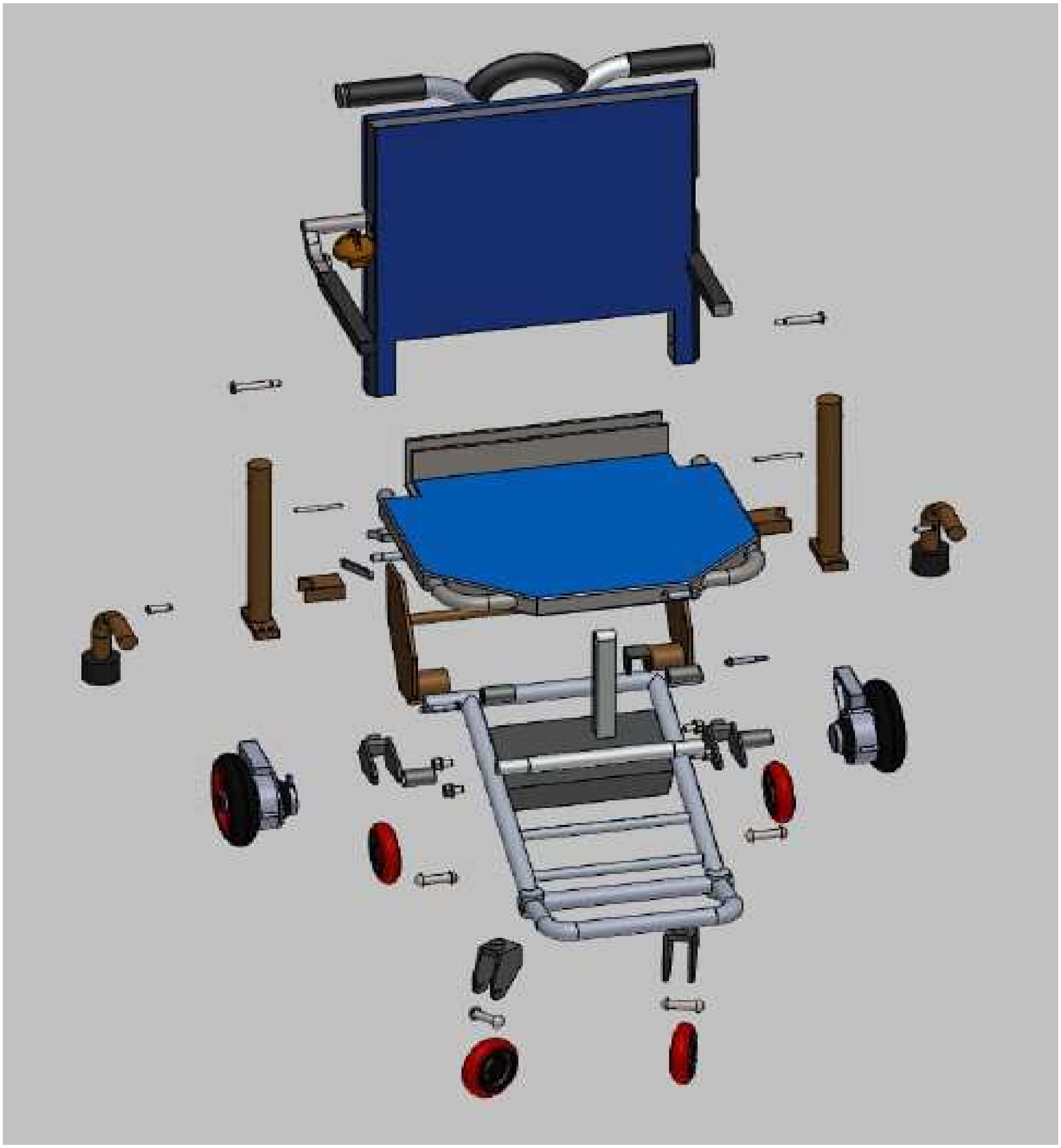


Figure Final Design (Exploded).

Figure Back view (unfolded position).

Figure Side view (unfolded position).

Figure Folded position.

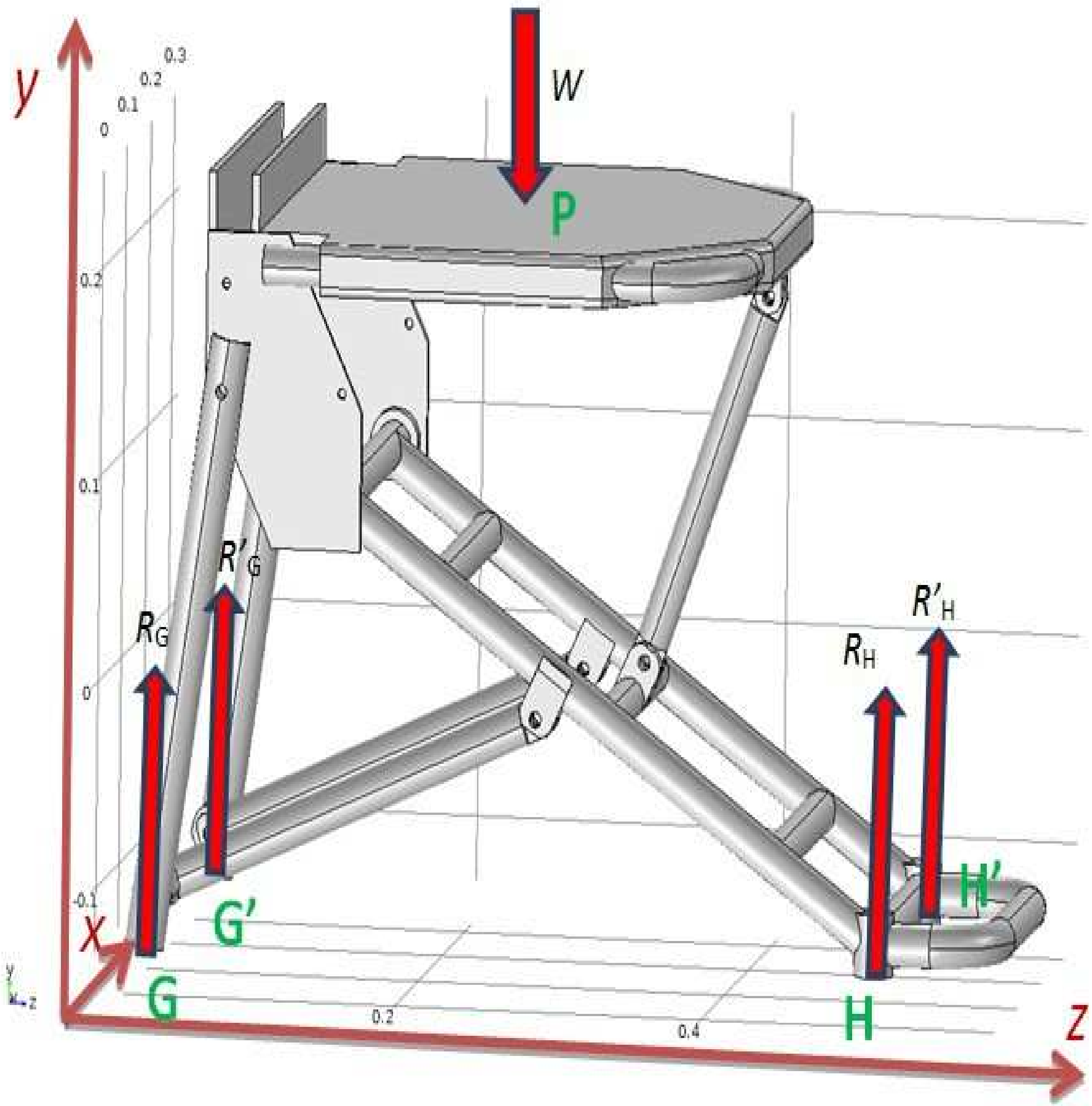


Figure External Equilibrium.

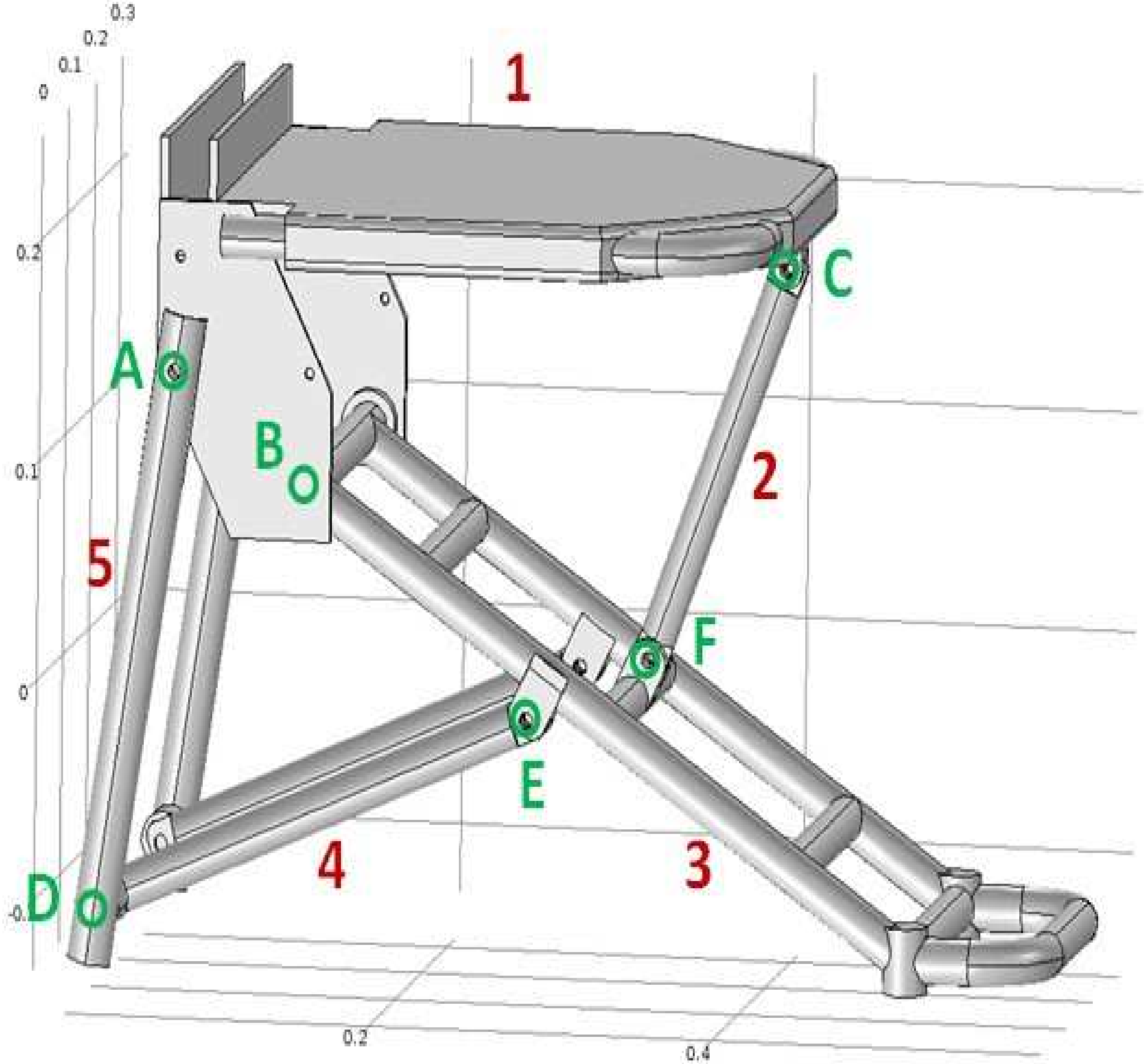


Figure Internal Equilibrium.

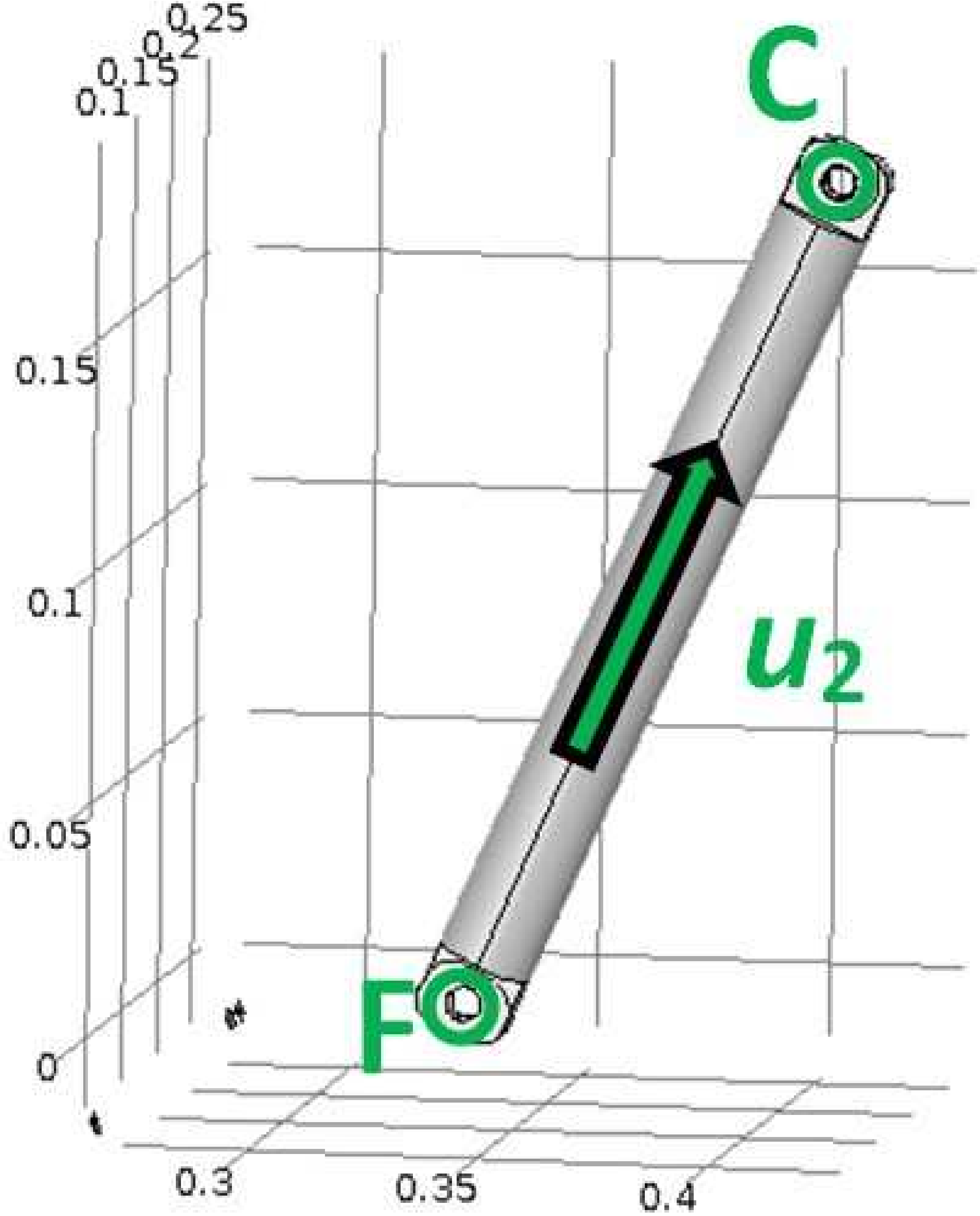


Figure Piece #2.

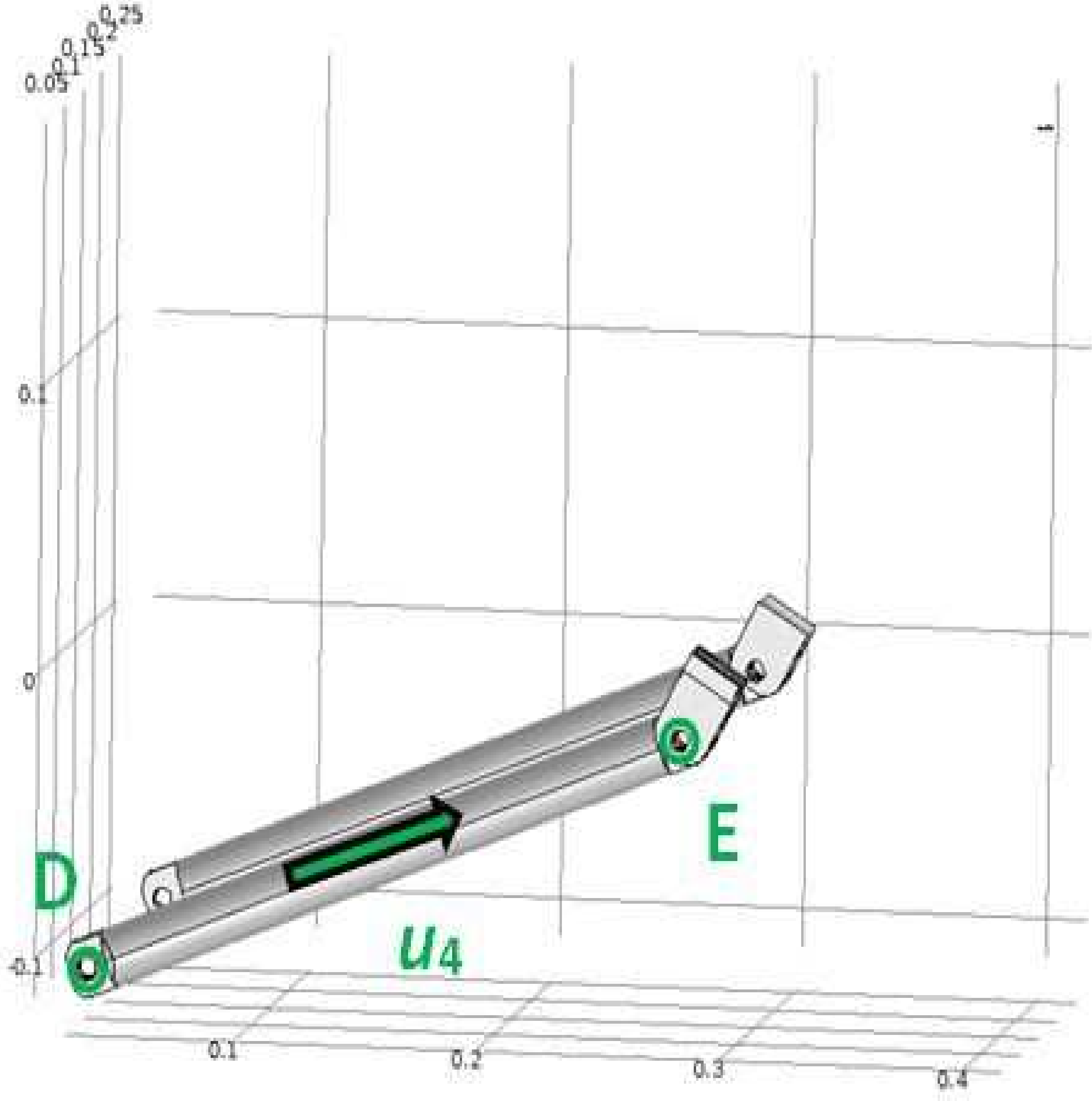


Figure Piece #4.

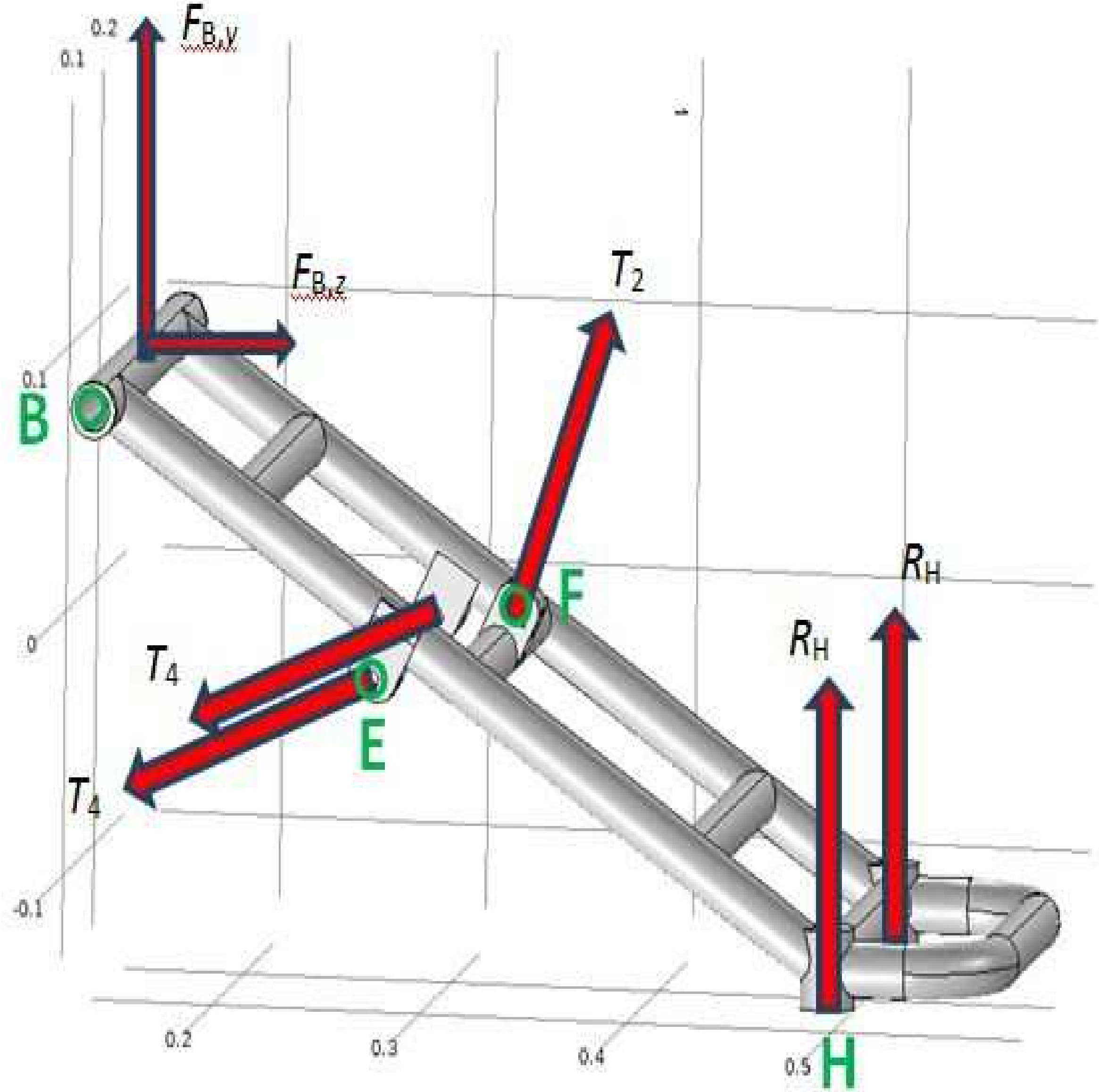


Figure Piece #5

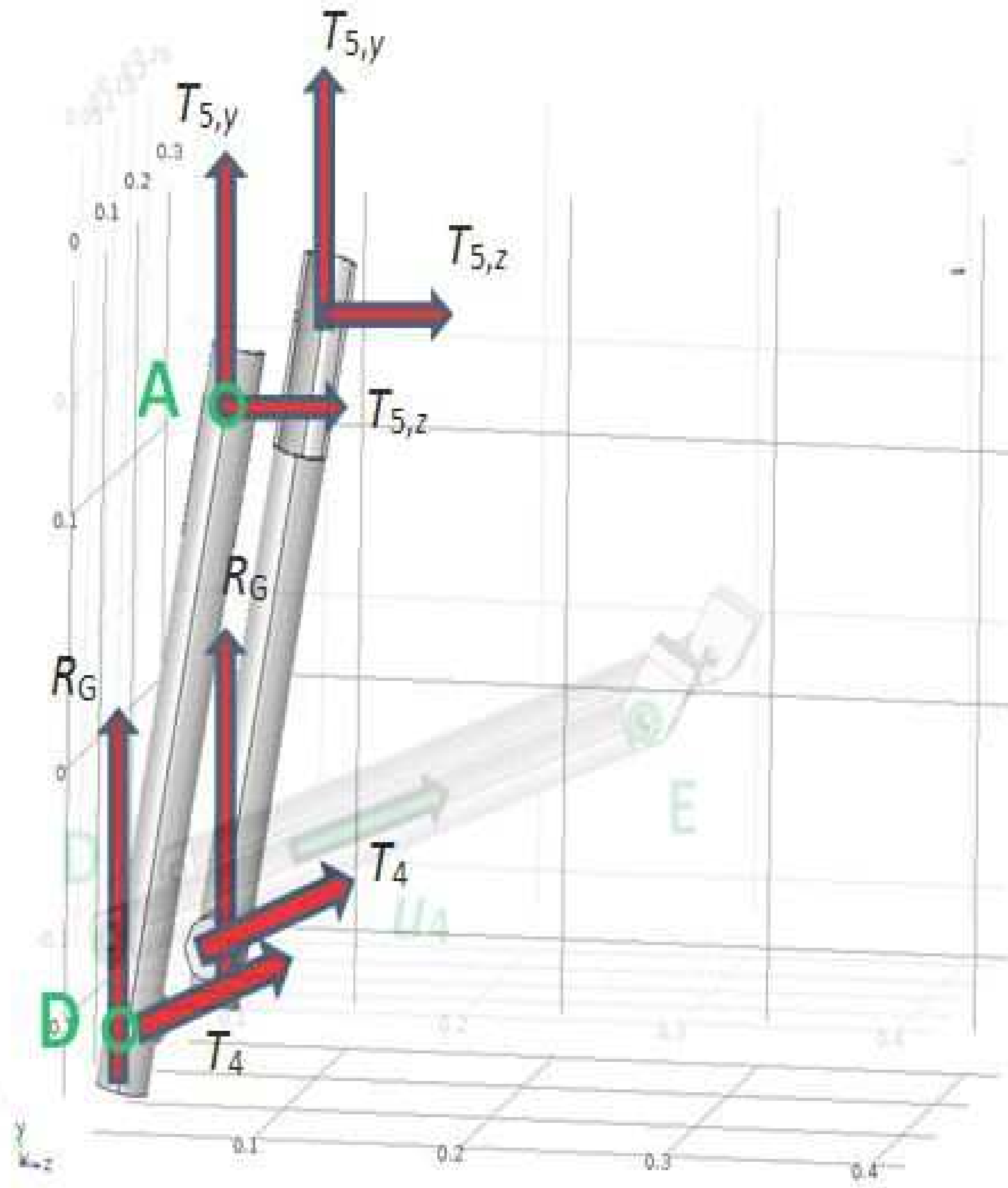


Figure Piece #3.

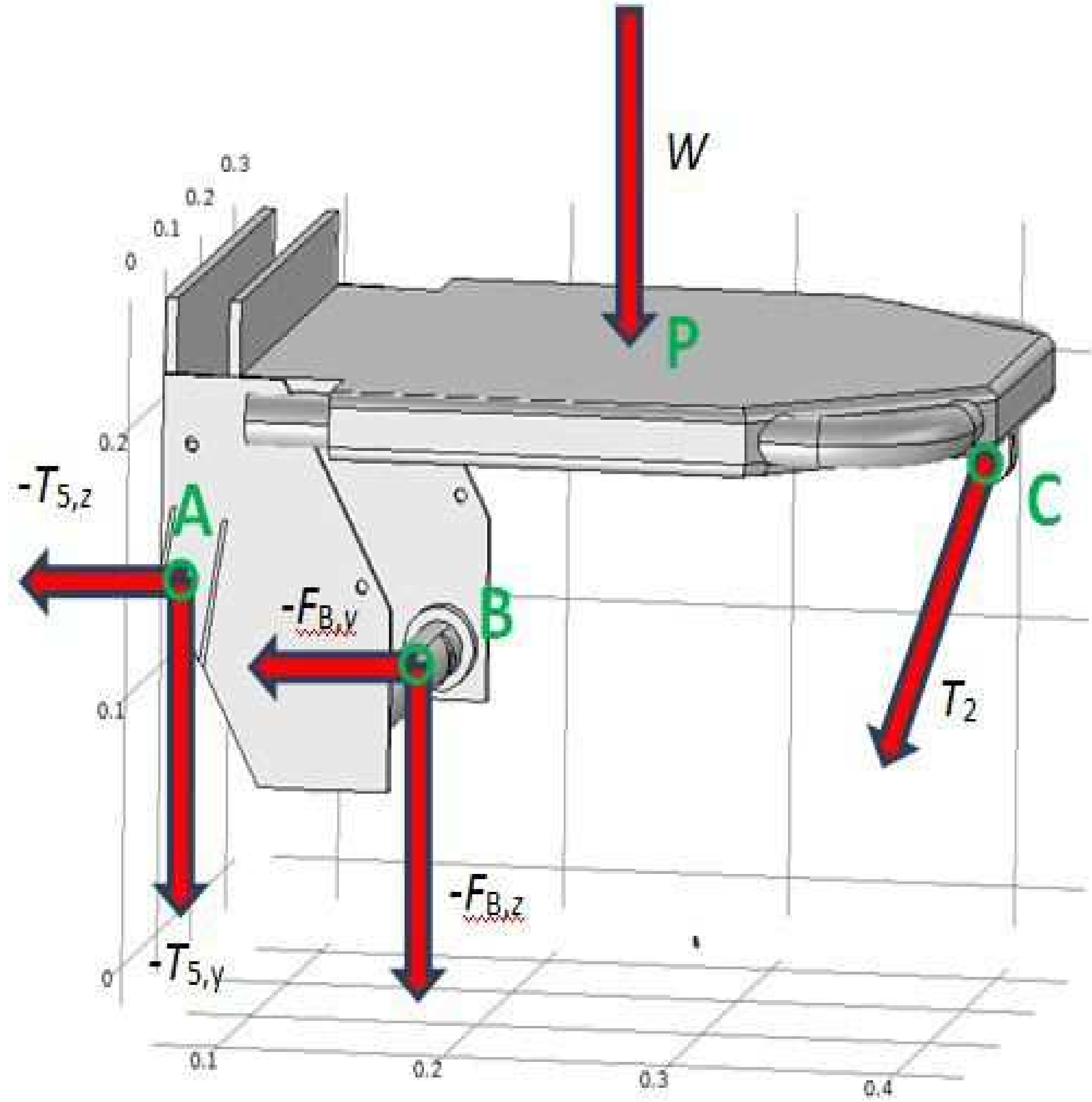


Figure Piece #1

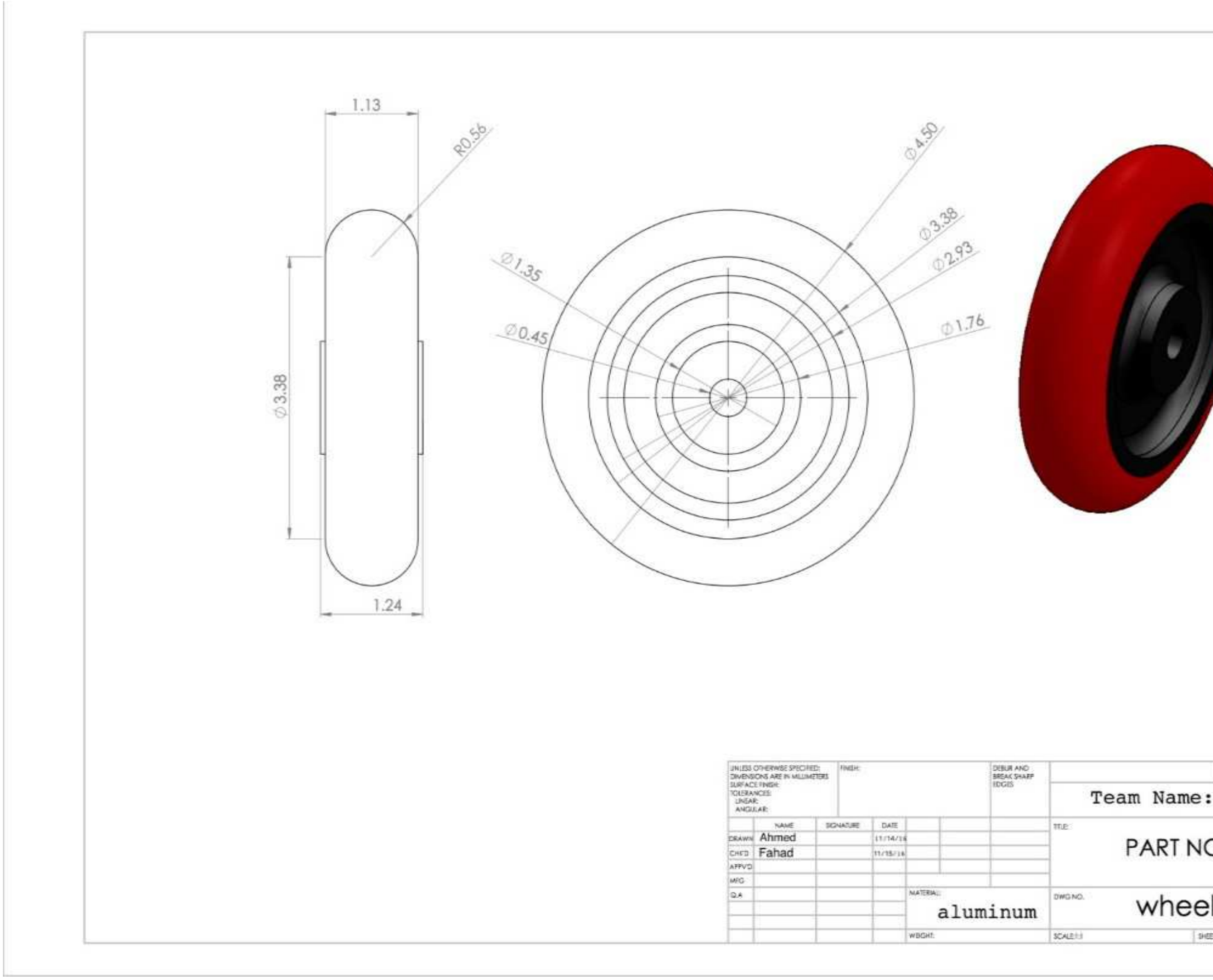


Figure wheel 2

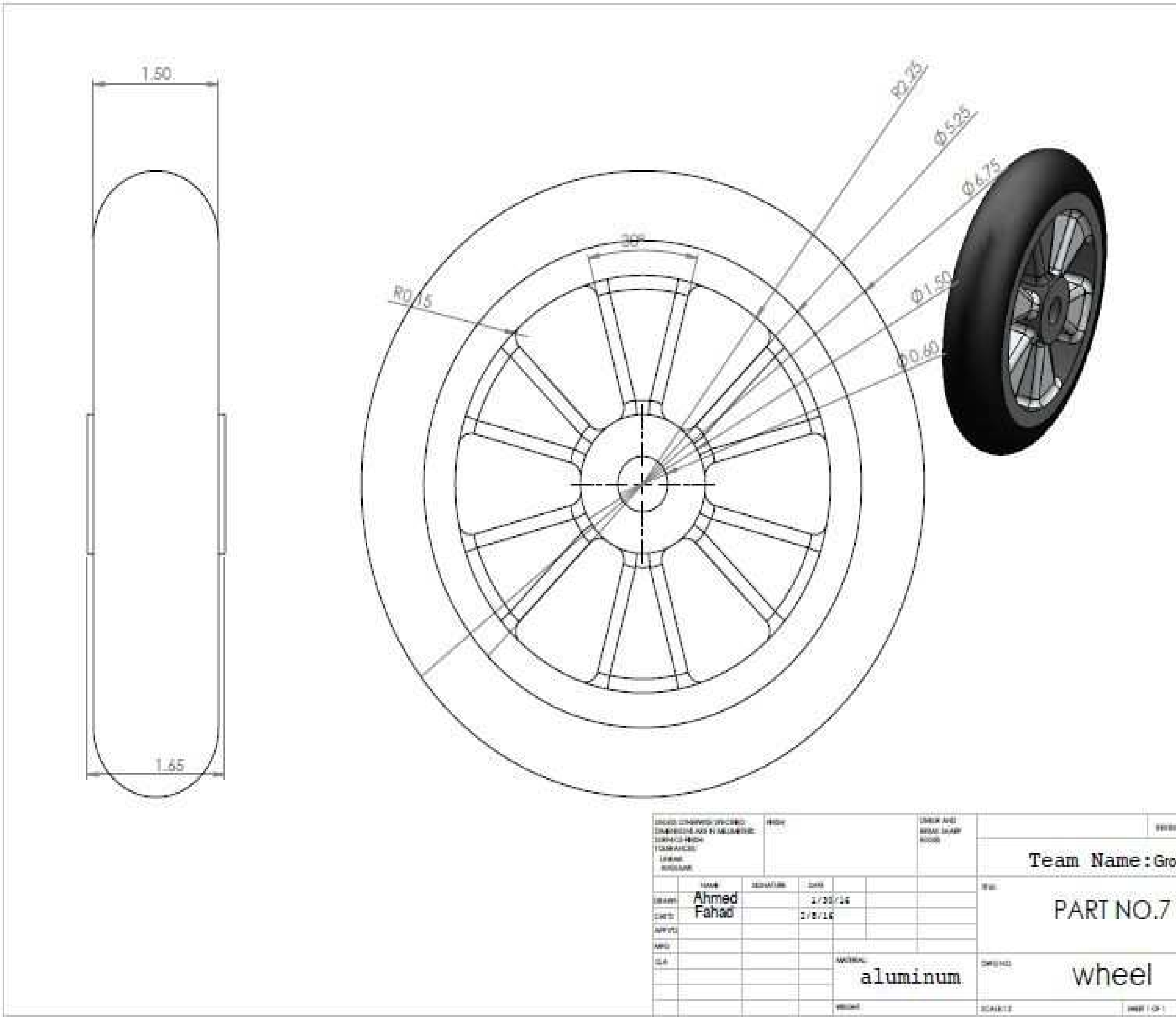


Figure Wheel

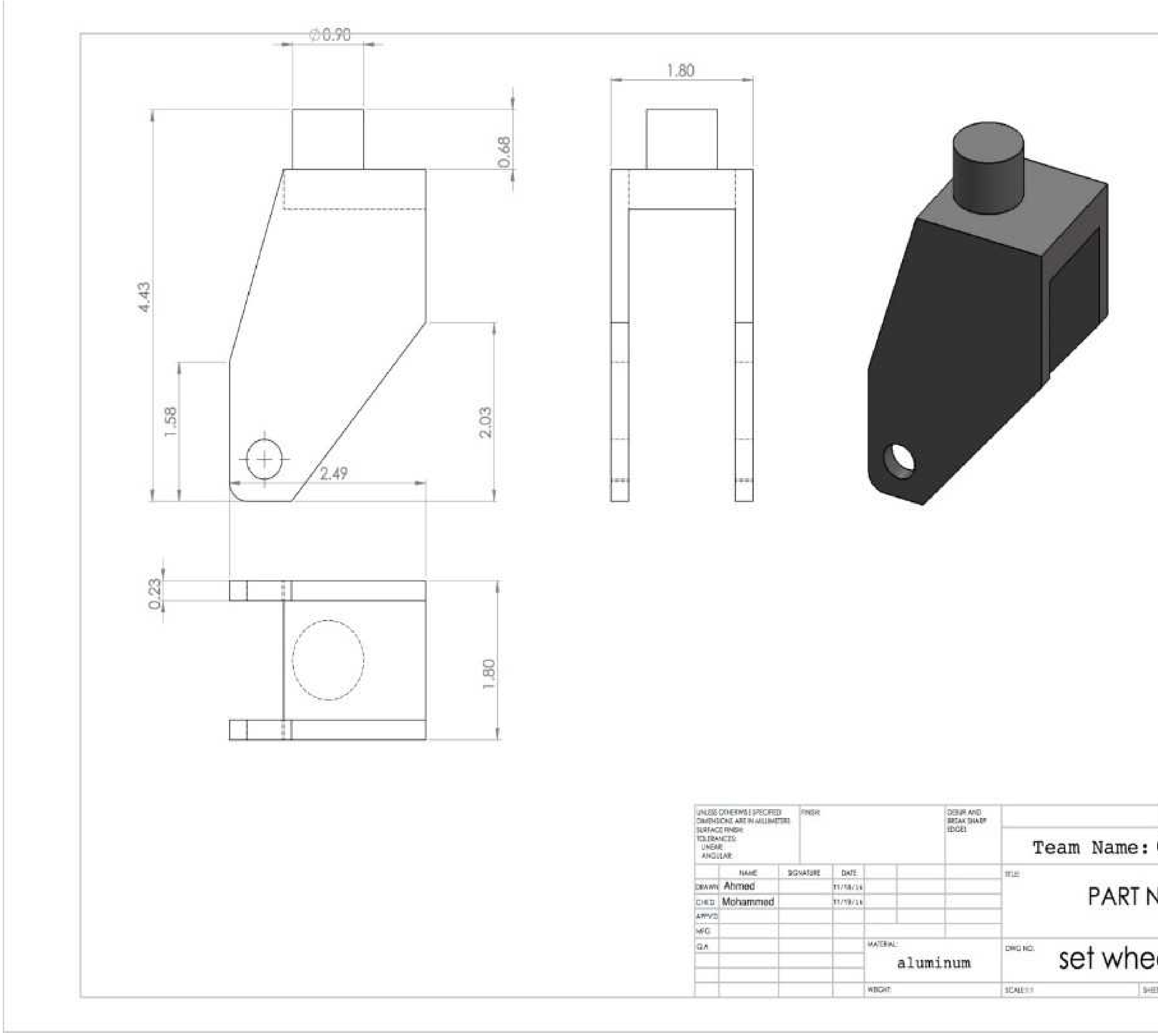


Figure Set Wheel 2

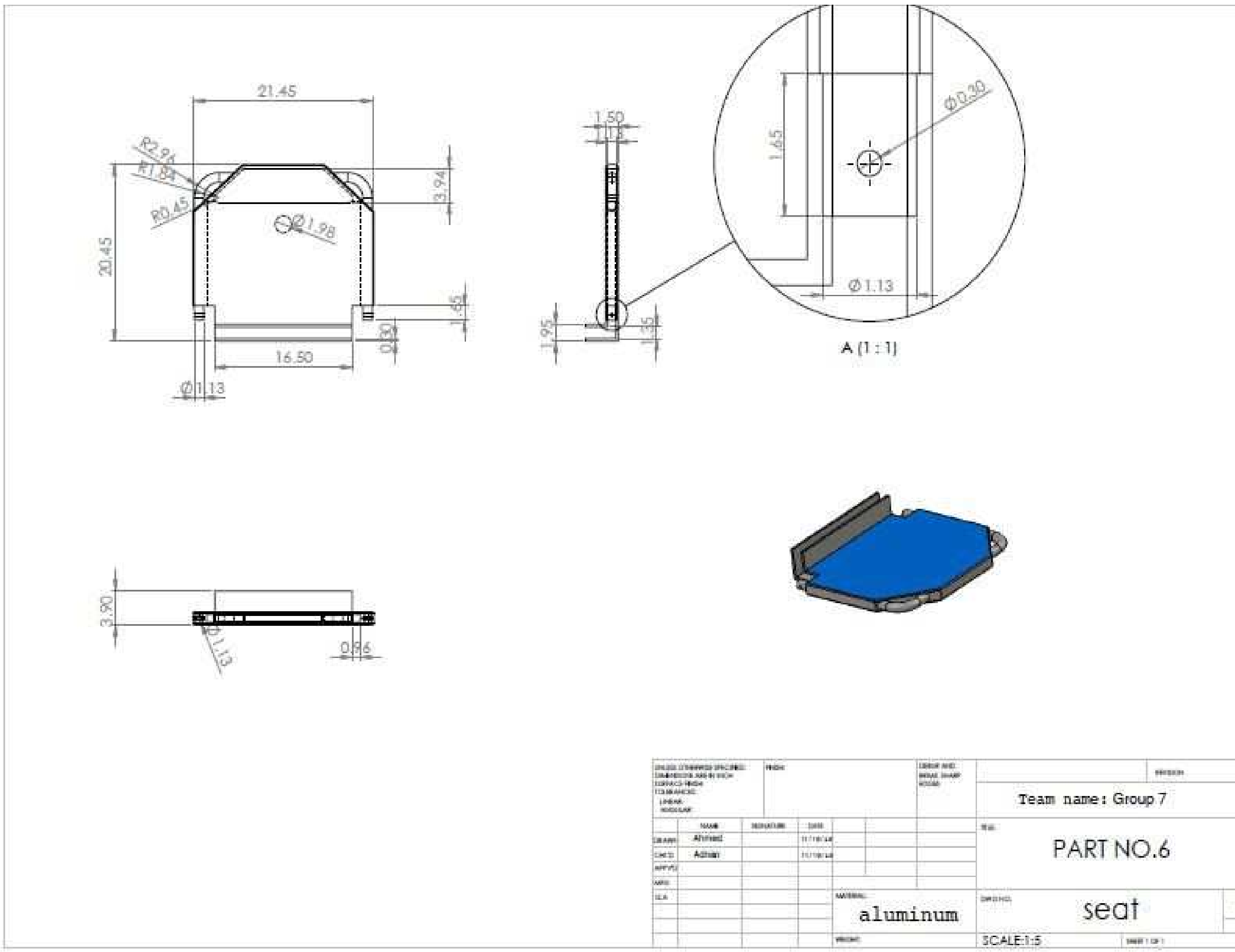

21.45
R2.96
R1.84
R0.45
Ø1.98
3.94
20.45
1.65
0.30
16.50
Ø1.13
1.50
1.95
1.35
Ø0.30
1.65
Ø1.13
A (1 : 1)
3.90
Ø1.13
0.96
Team name: Group 7
PART NO.6
aluminum
seat
SCALE:1:5
Ahmed
Adnan

Figure Seat

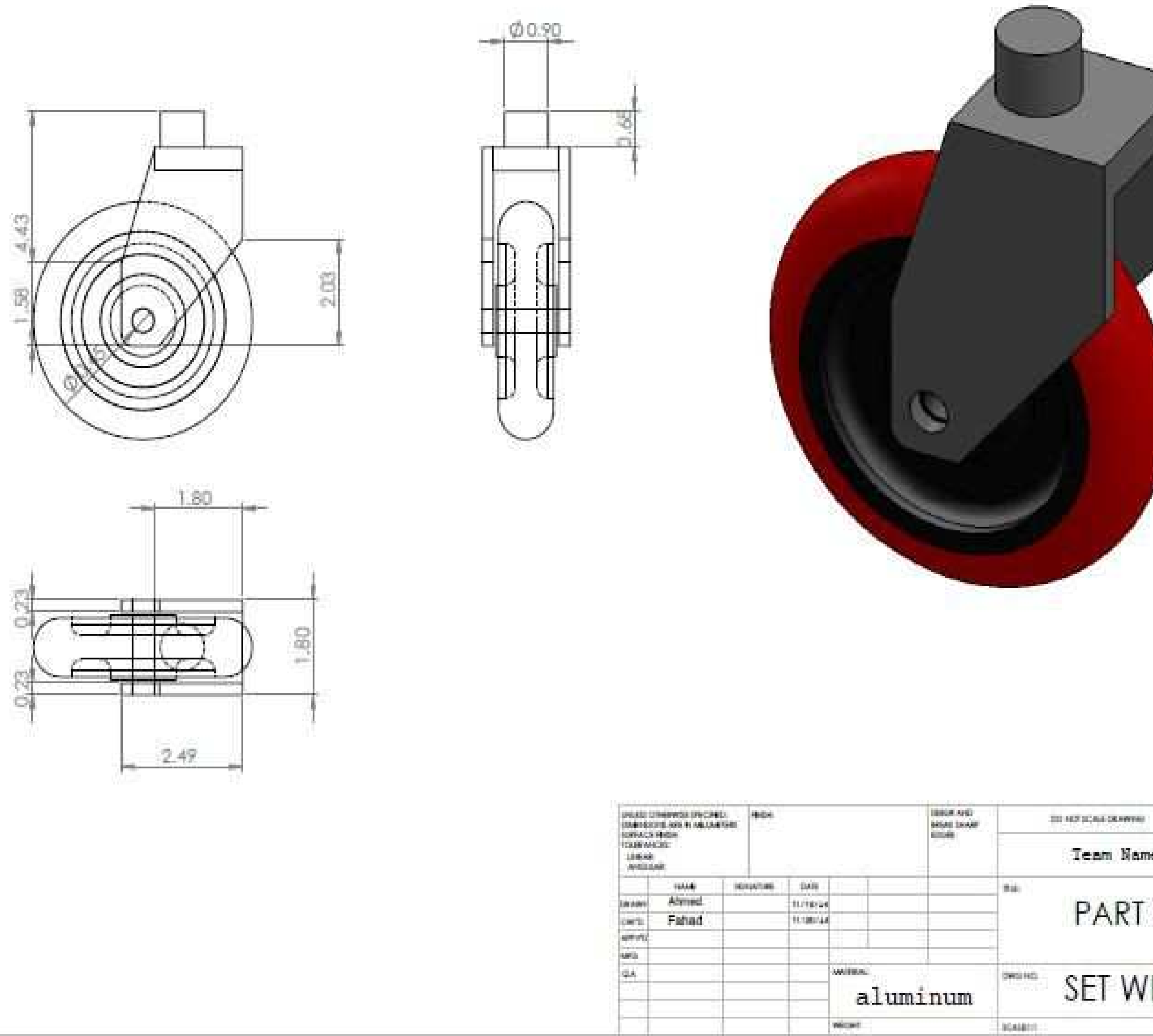


Figure Set Wheel 3

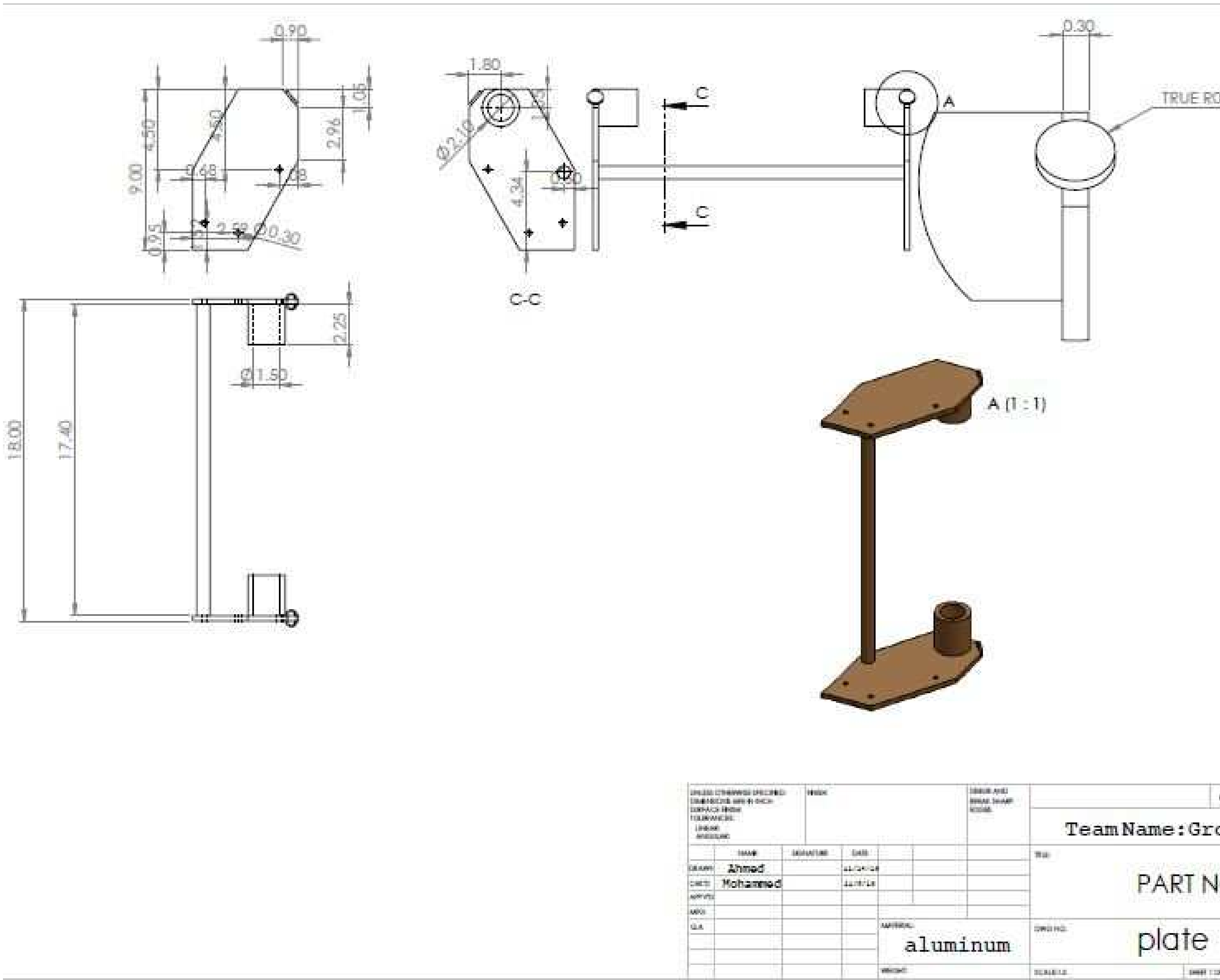


Figure Plate

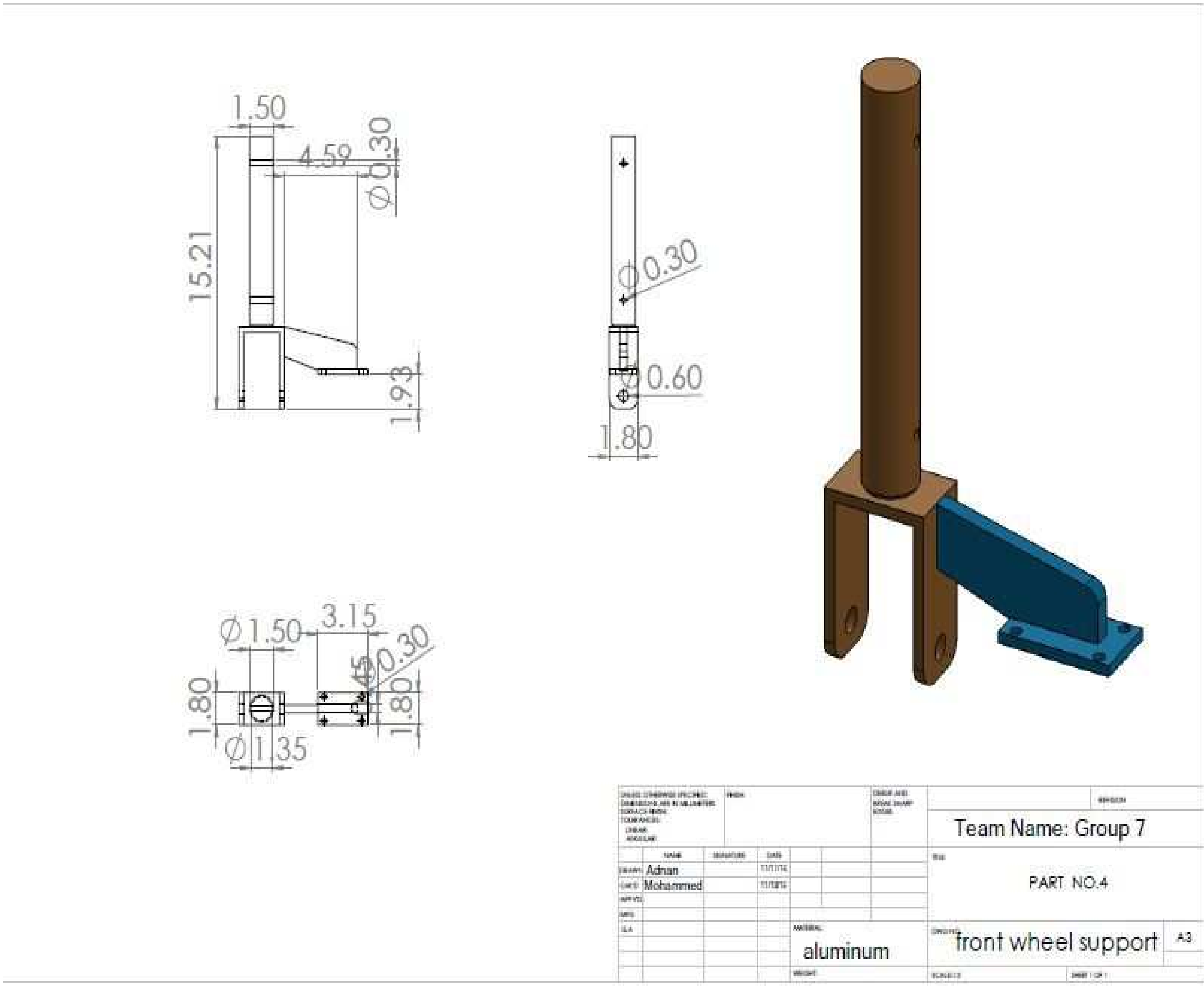


Figure Front Wheel Support

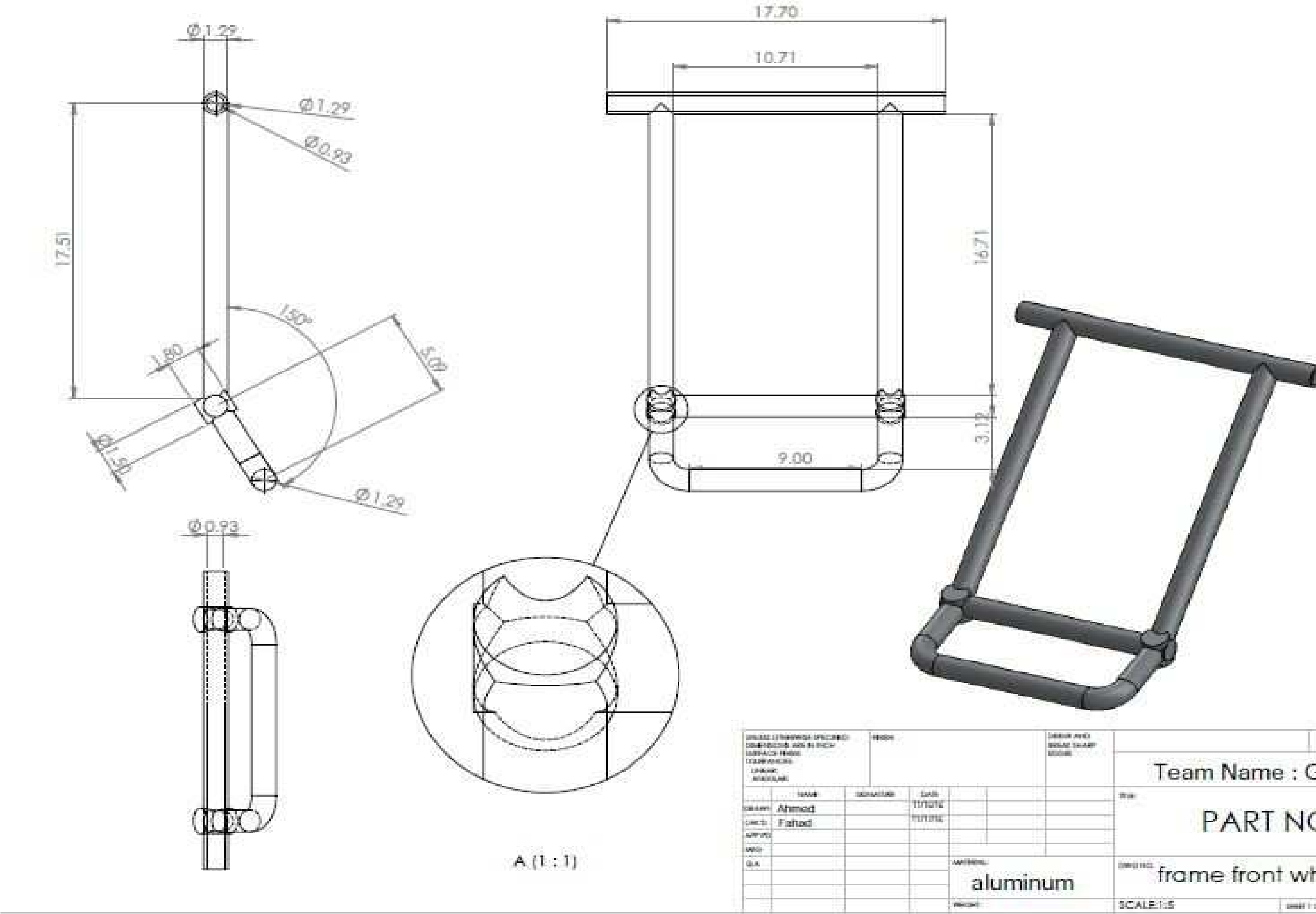


Figure Frame Front Wheels

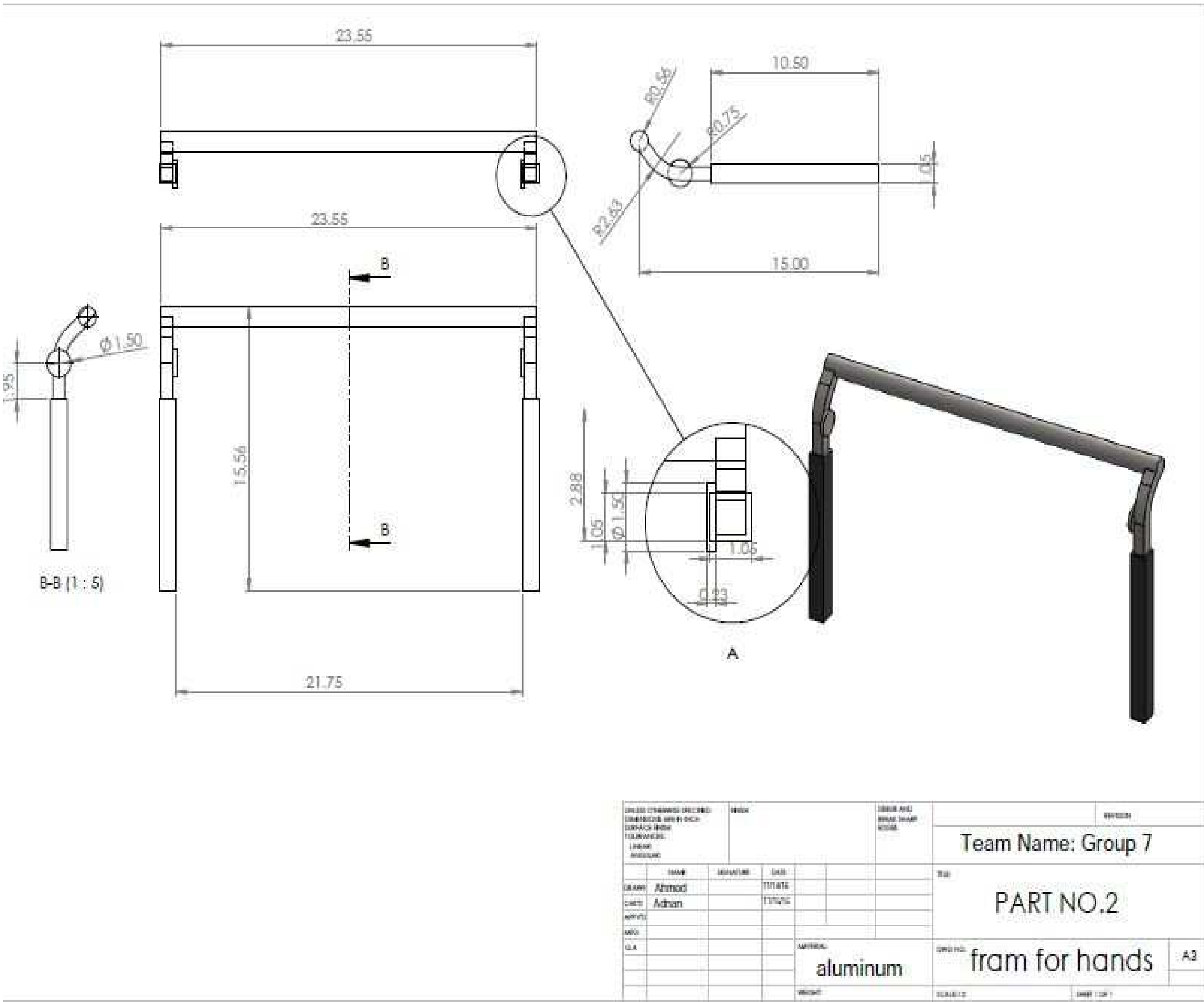


Figure Front for hands

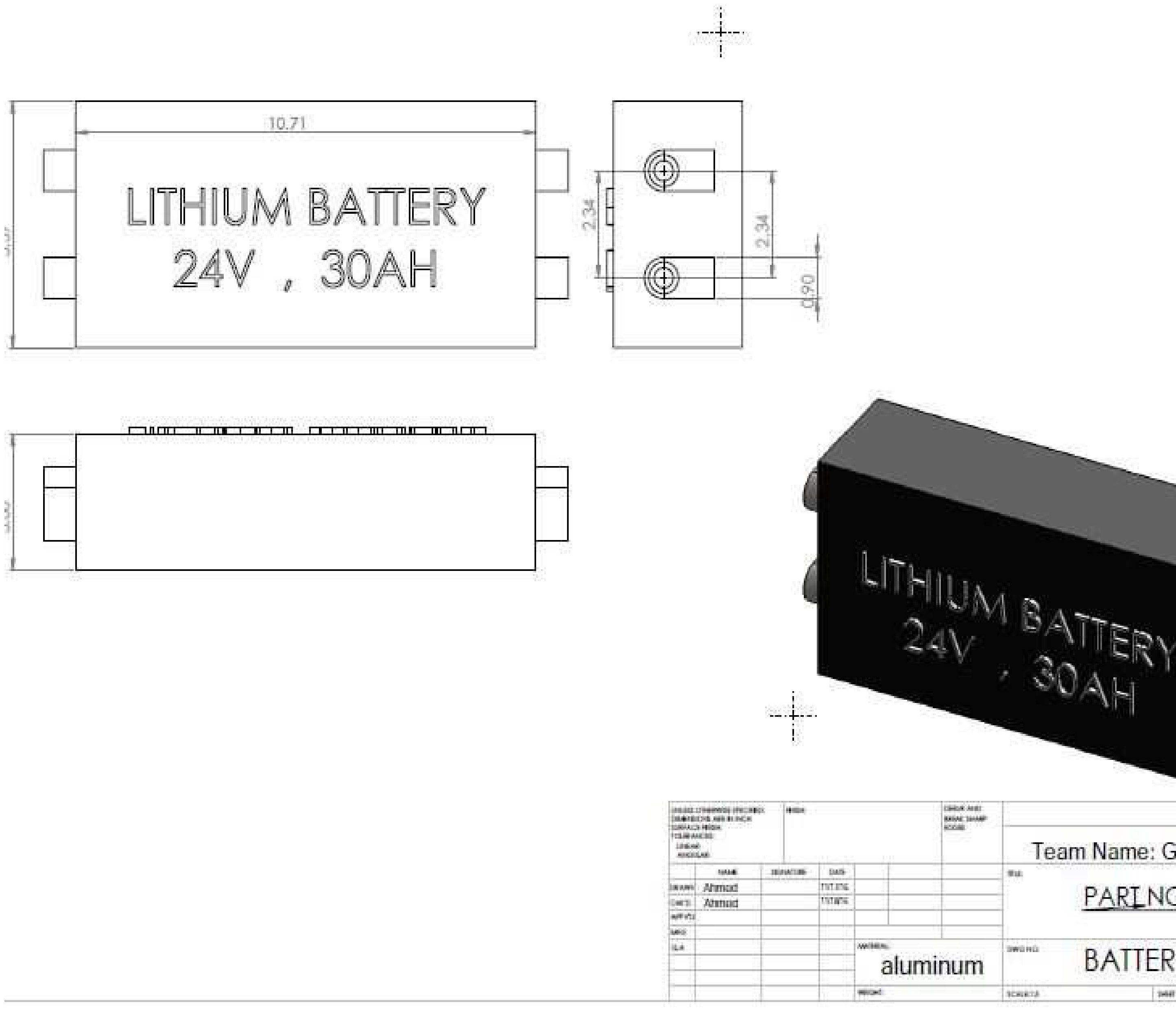


Figure Battery

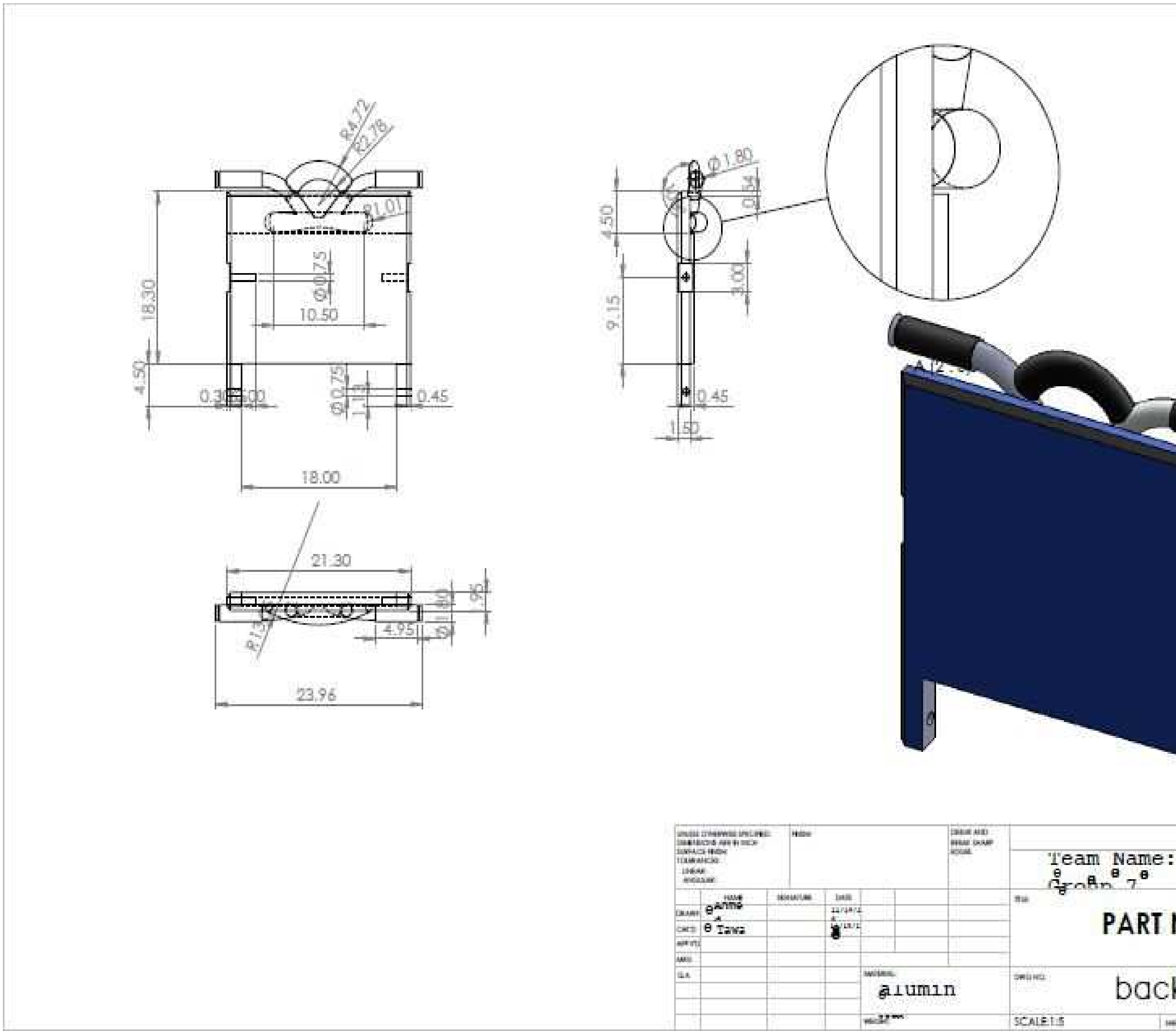

R4.72
R2.78
R1.01
Ø0.75
10.50
18.30
4.50
0.30
5.00
Ø0.75
1.19
0.45
18.00
21.30
1.80
.95
4.95
23.96
Ø1.80
0.54
4.50
9.15
3.00
0.45
1.50
Team Name:
PART
alumin
back
SCALE:1:5

Figure Back

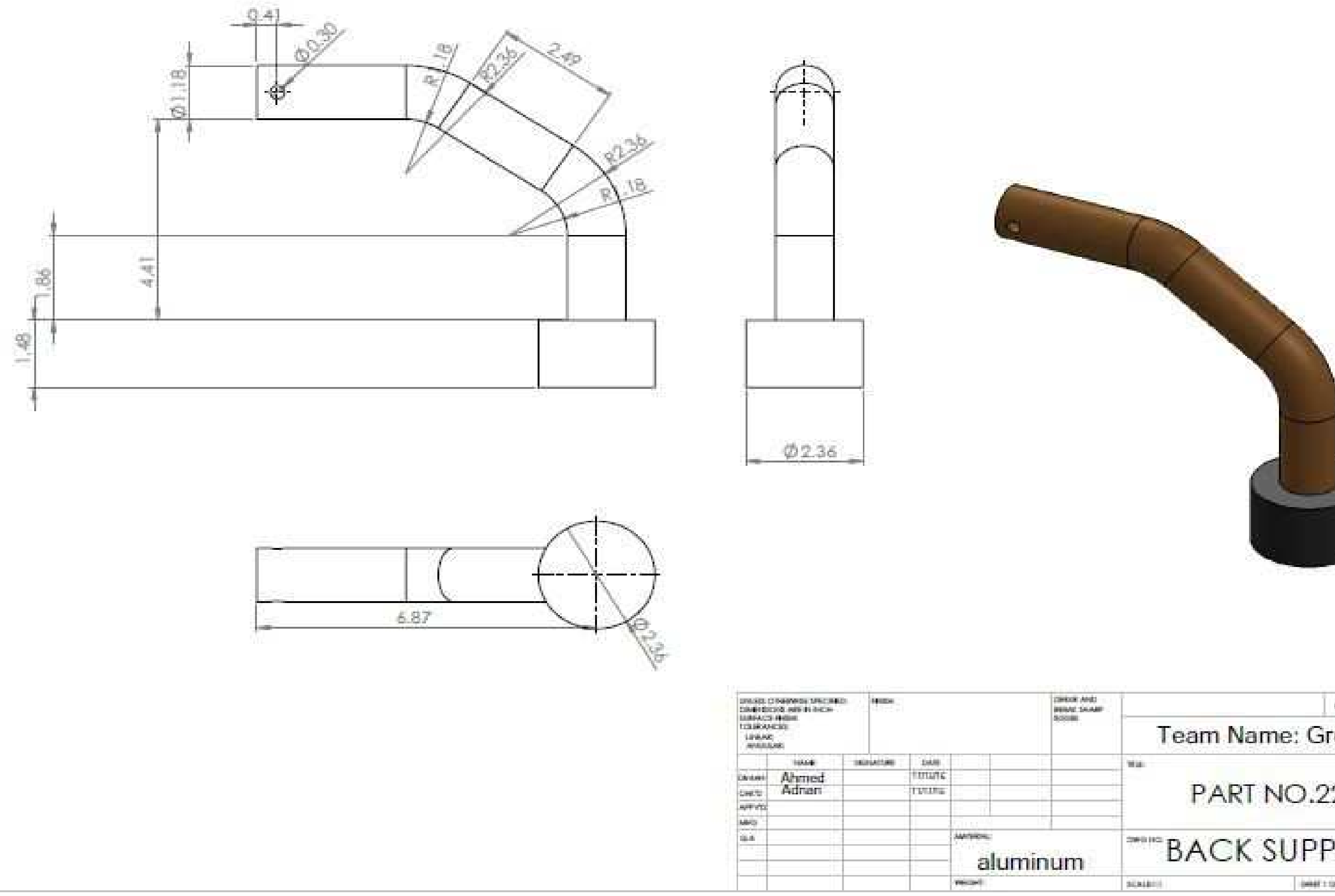
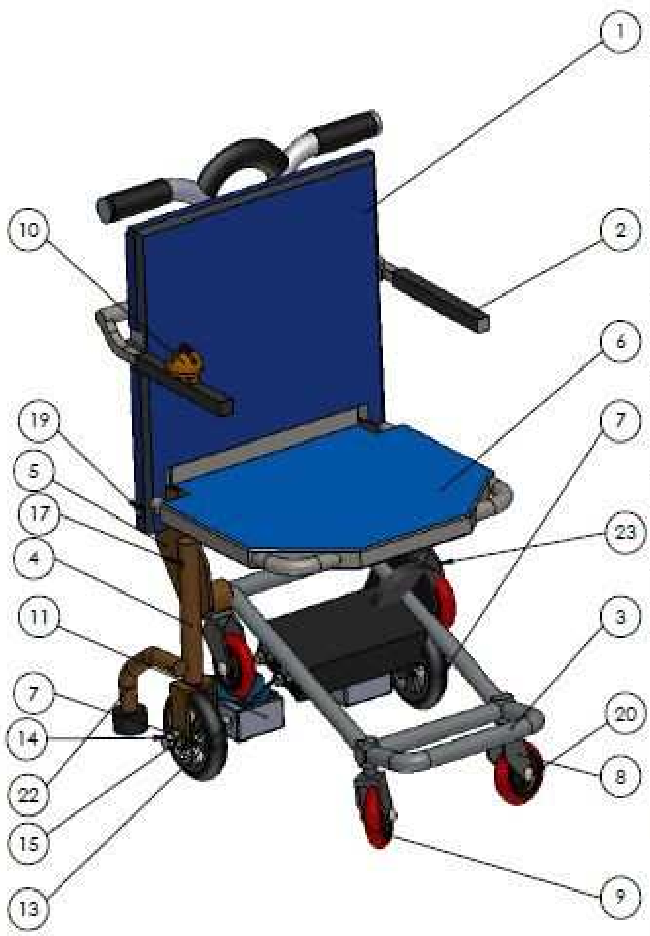


Figure Back Support



ITEM NO.	PART NUMBER	DESCRIPTION
1	back	
2	fram for hands	
3	frame front wheels	
4	front wheel support	
5	plate	
6	seat	
7	wheel	
8	set wheel 2	
9	wheel2	
10	control arm	
11	motor	
13	B18.2.3.9M - Heavy hex flange screw, M8 x 1.25 x 12 --12N	
14	B18.2.3.5M - Hex bolt M10 x 1.5 x 60 --26N	
15	AM-M12-N	
16	ASME B18.8.2 - 0.1877x2	
17	0.3125-Clevis Pin	
18	0.25-Clevis Pin	
19	DIN 1445-8x50-St-N	
20	DIN 124-10x48-St-A-32	
21	back support 1	
22	back support	
23	SET WHELL3	

1 : 5
Team Name : Group 7
Ahmed
Adnan
Assemply
final proje

Figure Final Project

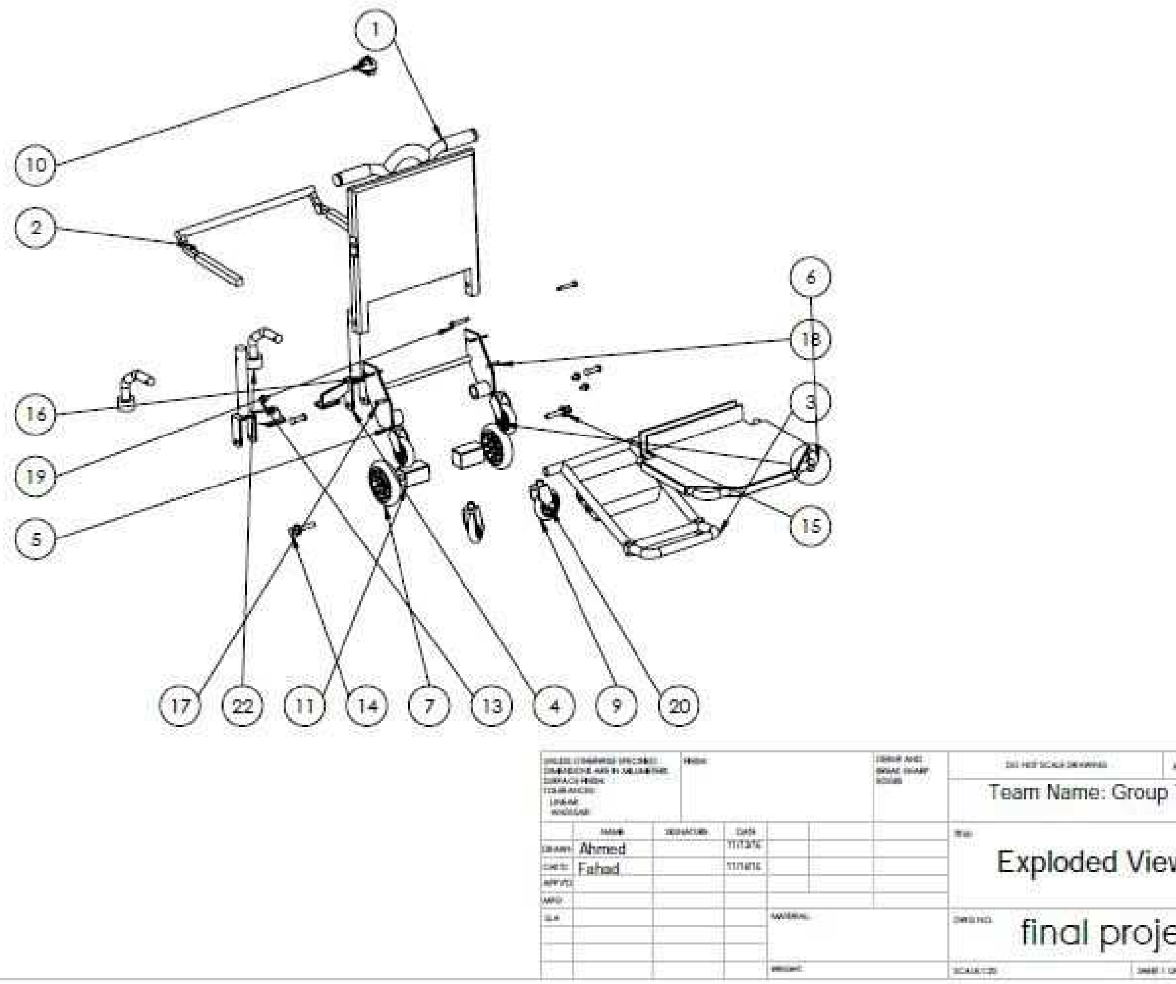


Figure Final Project

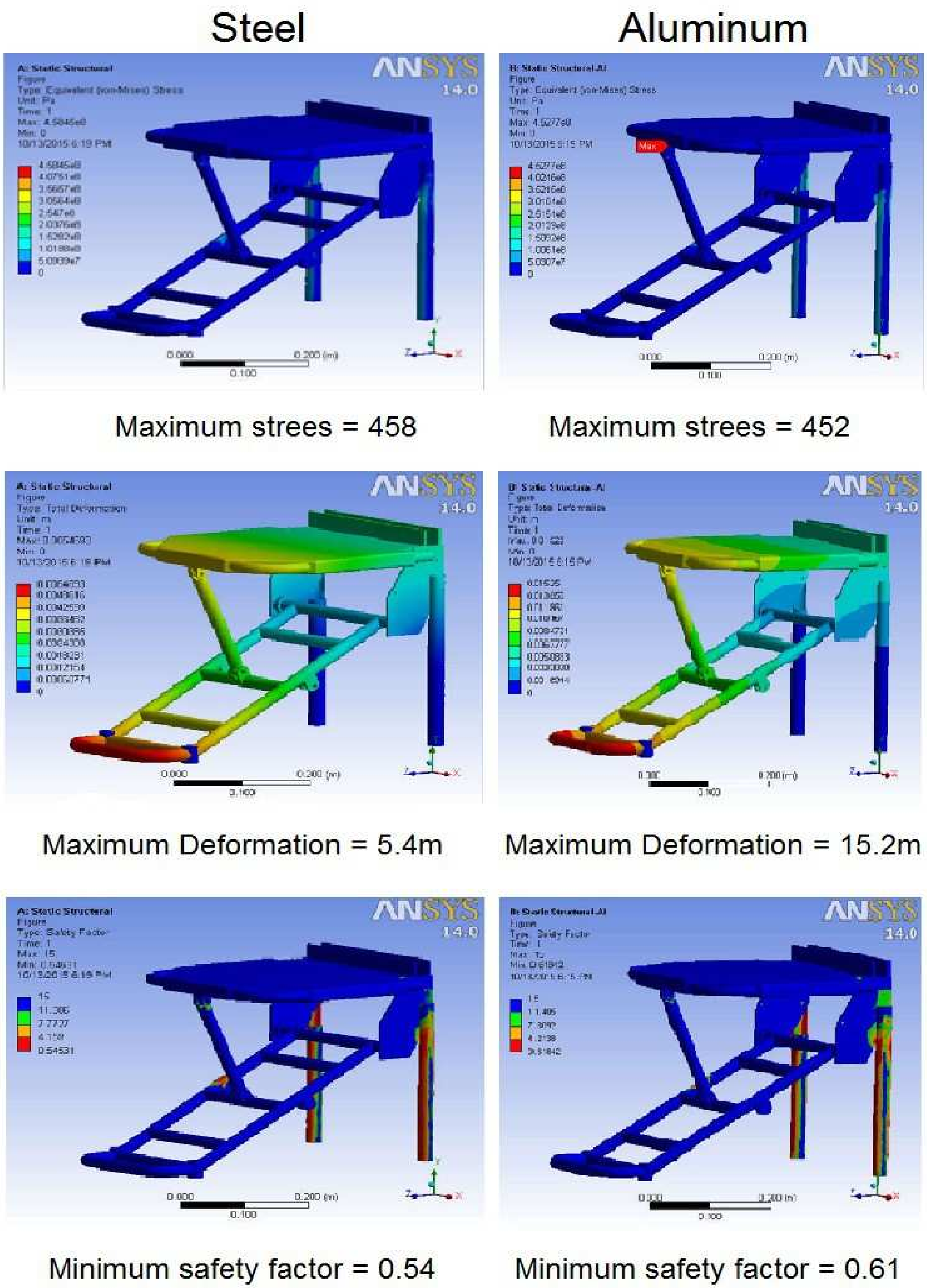


Figure A comparison between Mild steel and Aluminum to determine the optimum material for the project.

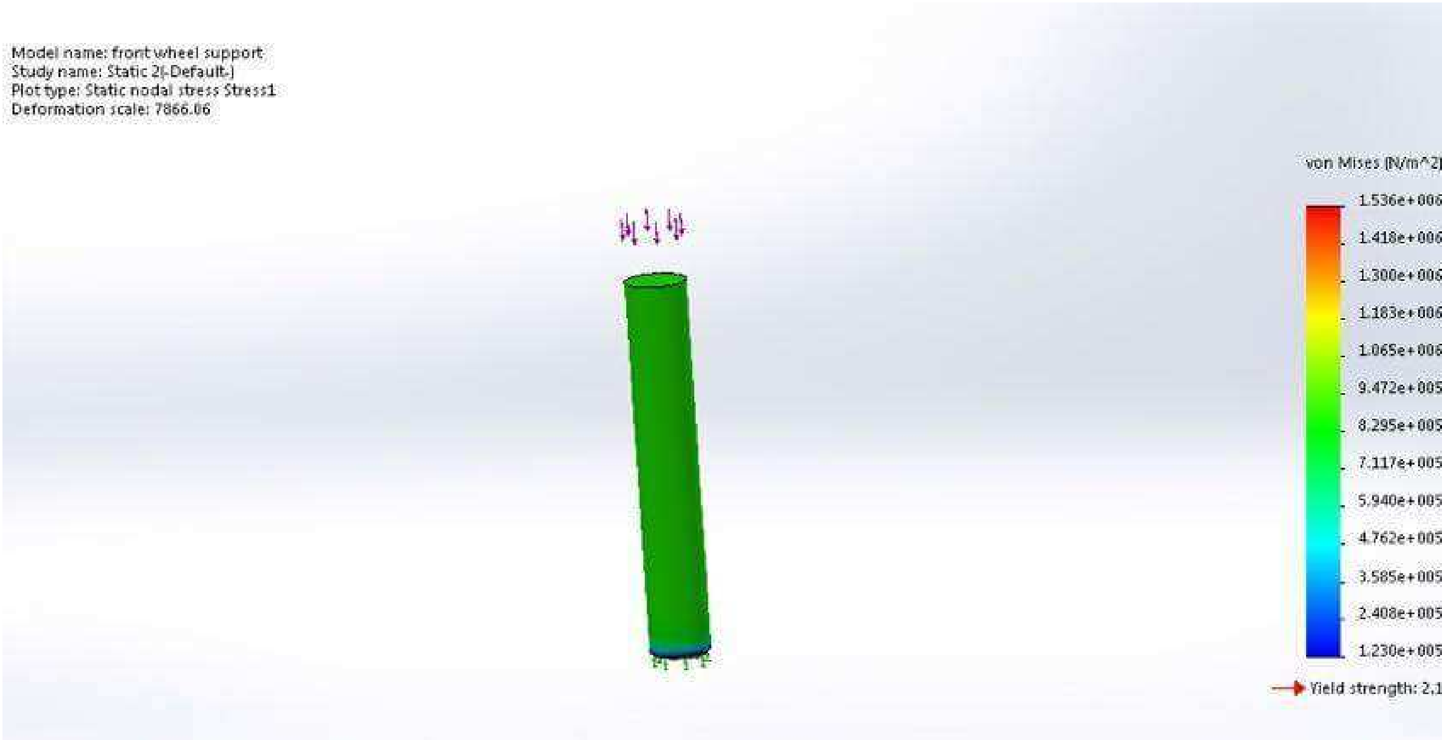


Figure Static nodal stress at the front wheel support.

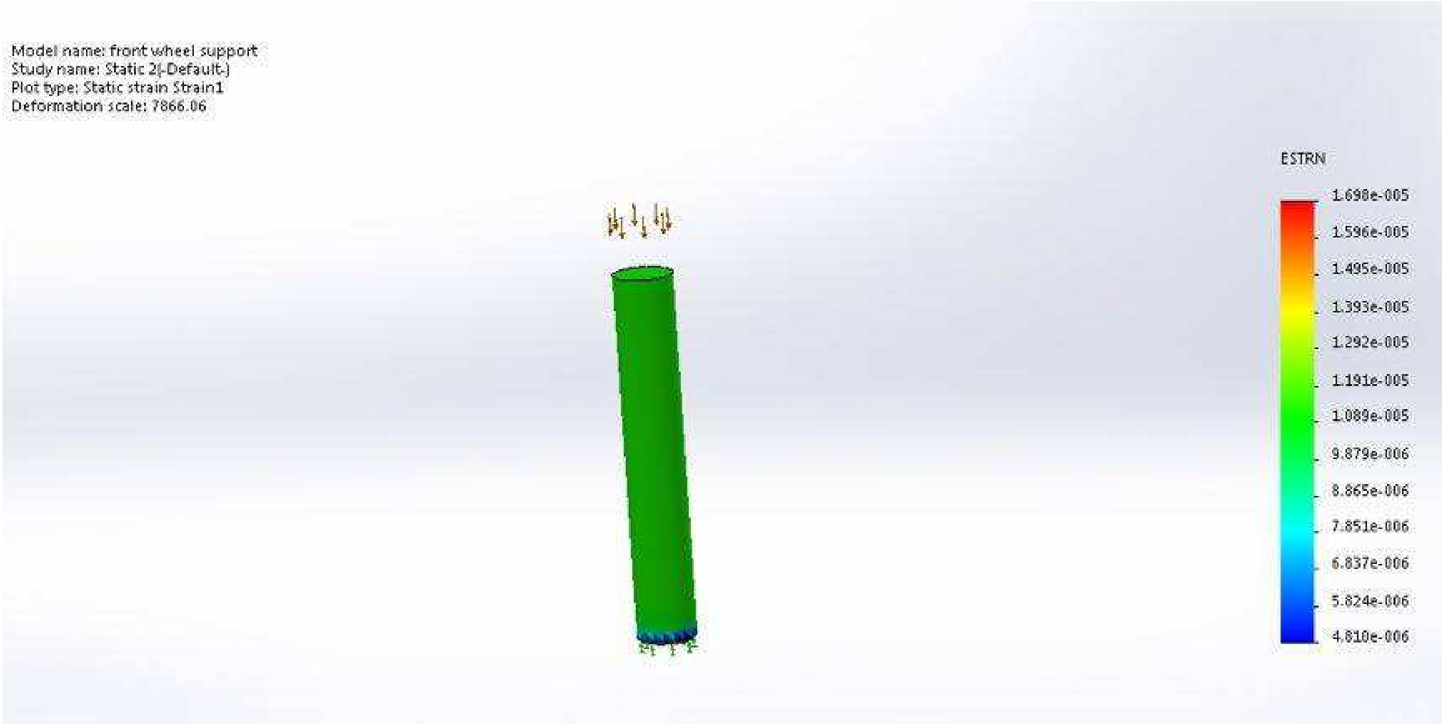


Figure Static strain at the front wheel support.

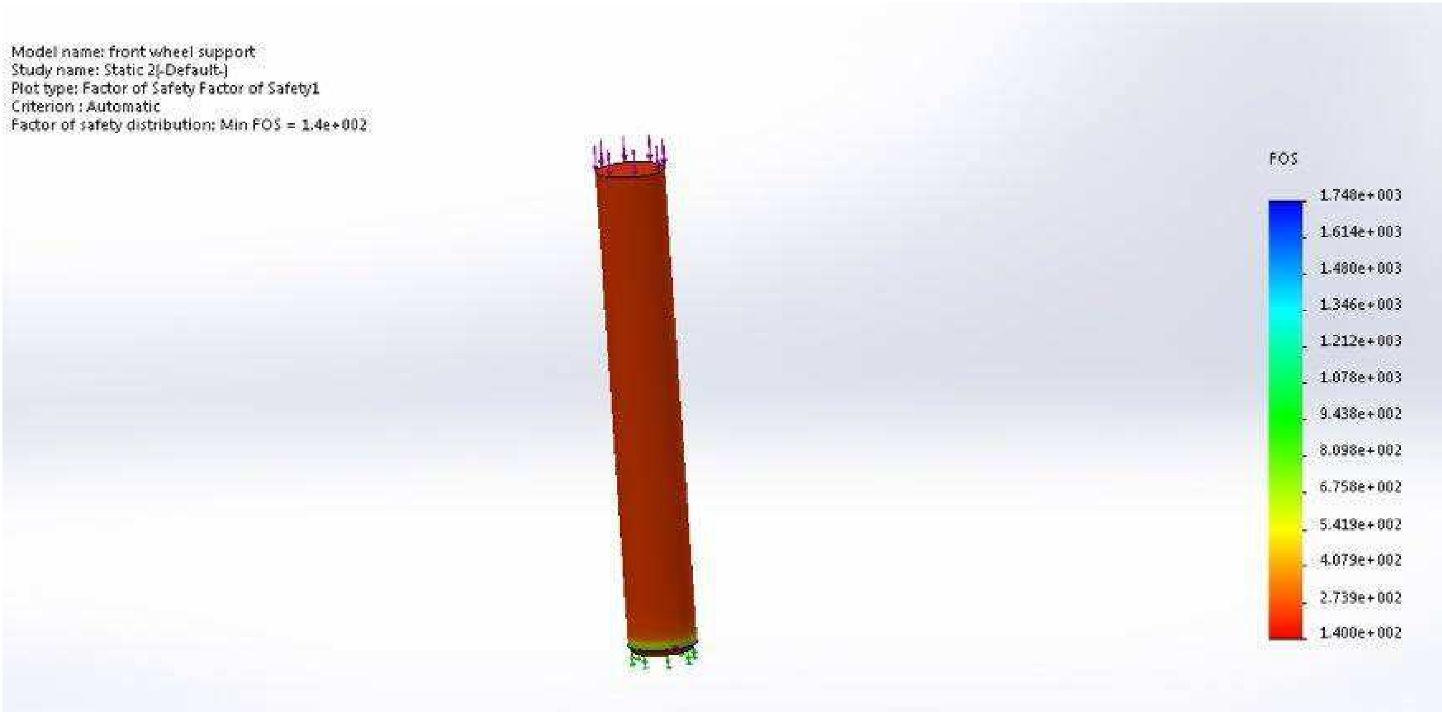


Figure Factor of safety for the front wheelsupport.

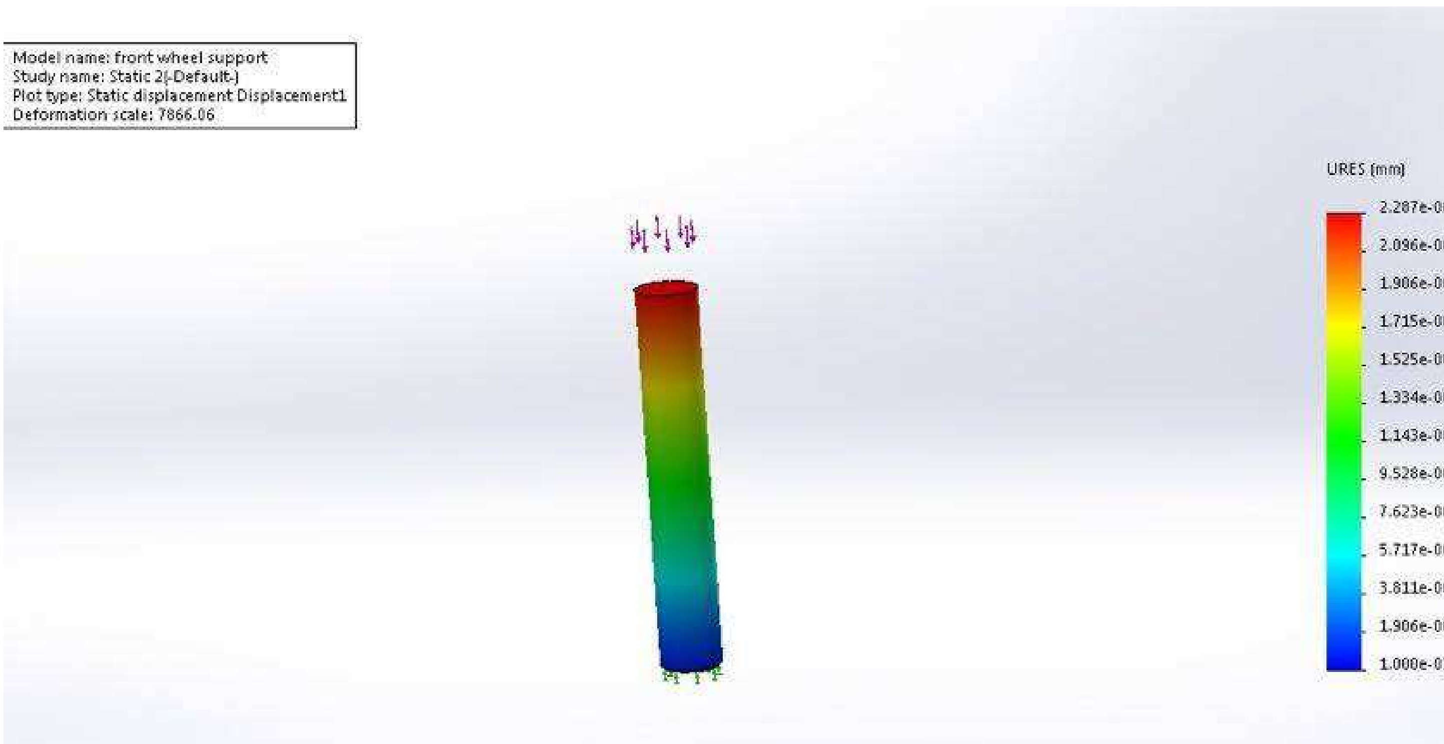


Figure Static displacement at the front wheel support.

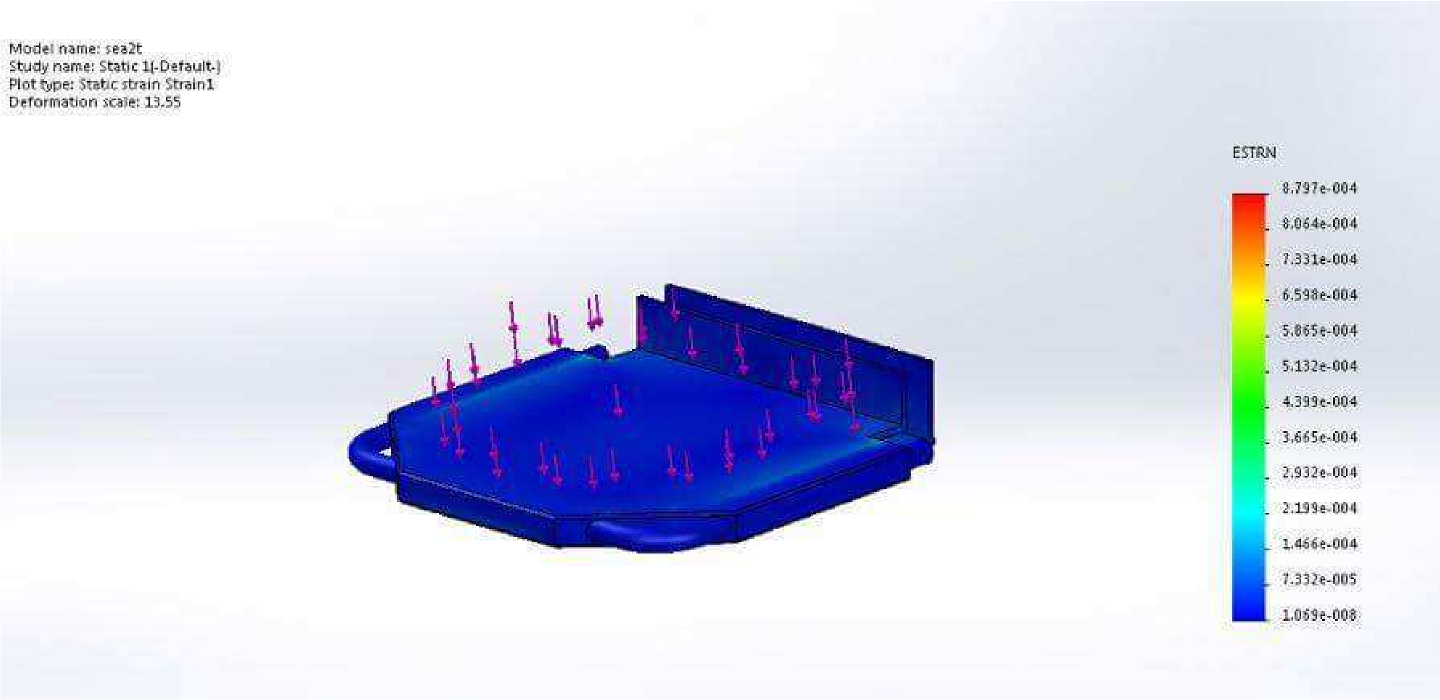


Figure Static strain at the seat.

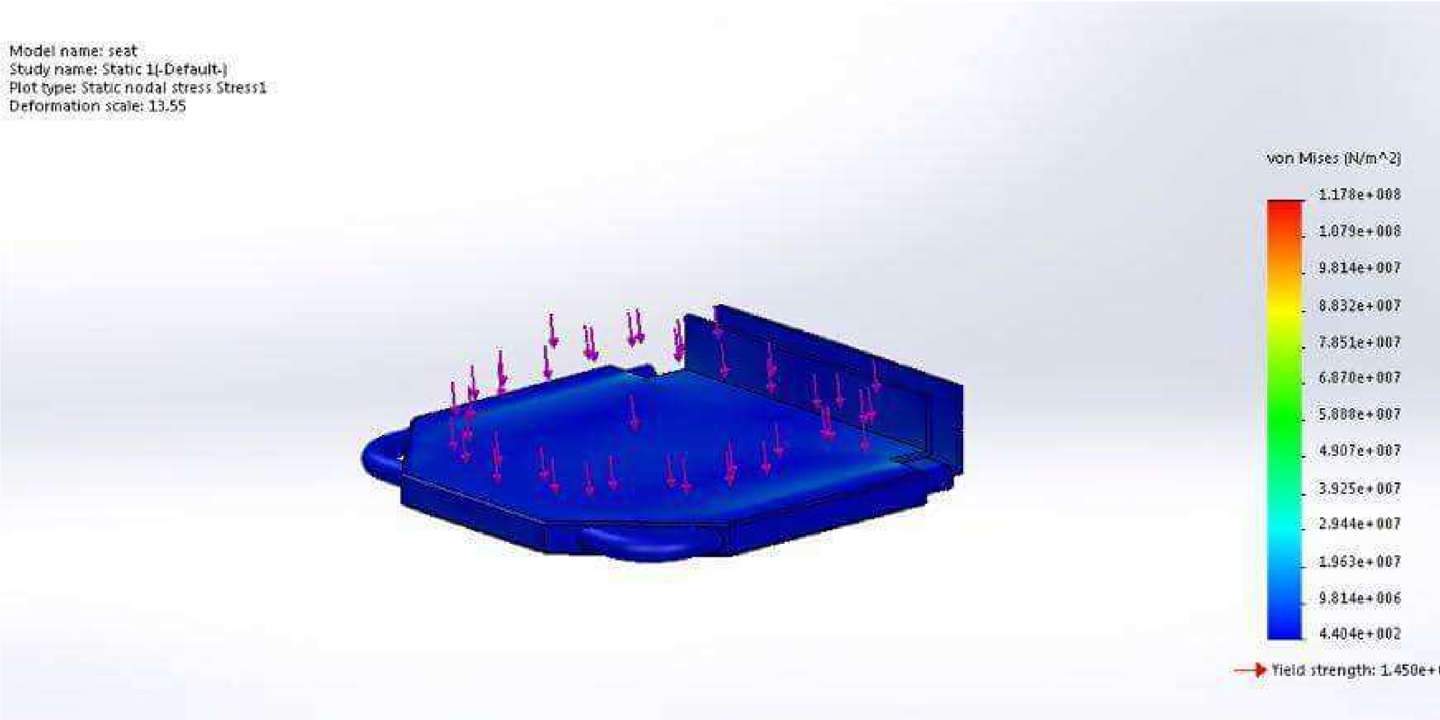


Figure Static nodal stress at the seat.

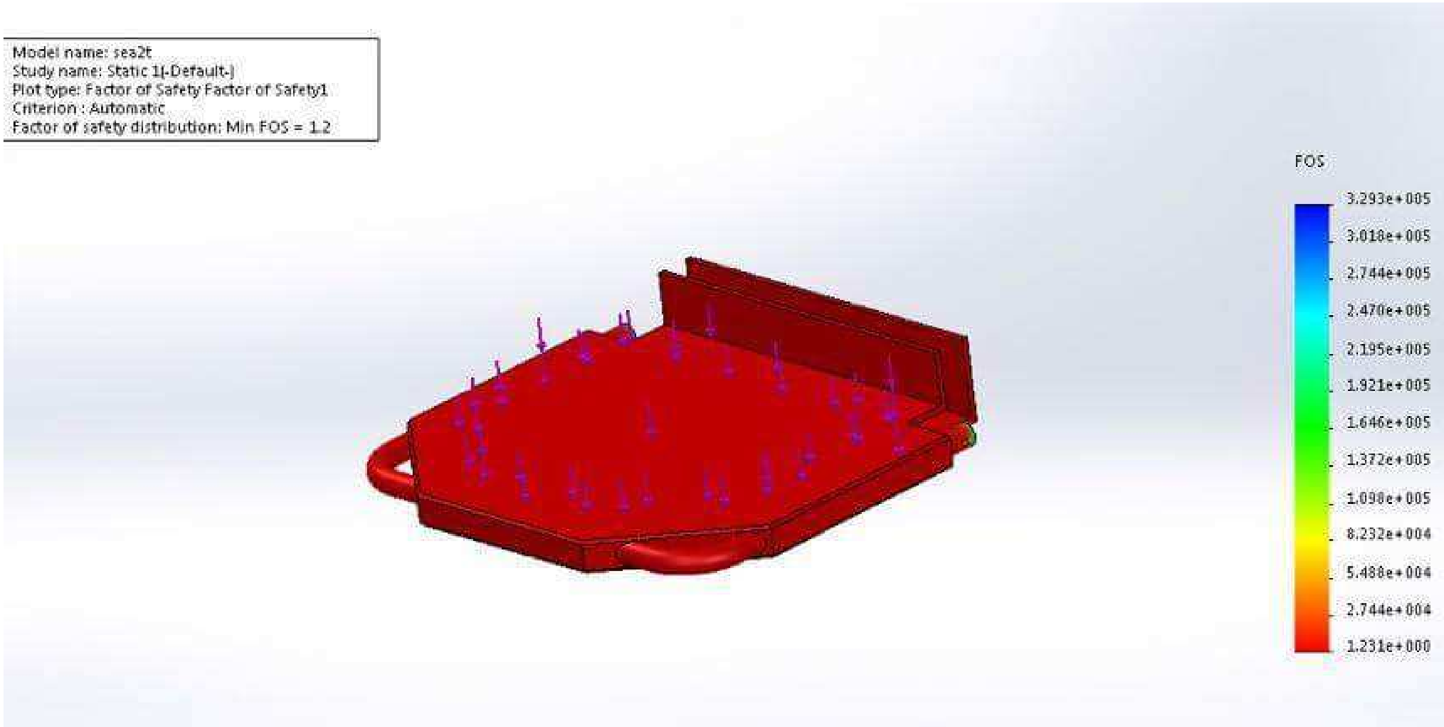


Figure Factor of safety for the seat.

Appendix B: Tables and Charts:

Table (1). Bill of Materials:

ITEM No.	PART NAME	DRG. NO.	QTY.	Make/Buy
1	BACK	WC-001	1	Make
2	FRAME FOR HAND	WC-002	1	Make
3	PLATE	WC-003	1	Make
4	FRAME FRONT WHEELS	WC-004	1	Make
5	FRONT WHEELS	WC-006-1	2	Make/Buy
6	WHEELS	--	2	Buy
7	SEAT	WC-006	1	Make
8	Battery		1	BUY
9	Gears		2	BUY

10	Servo Motors		1	BUY
11	DC Motor		1	BUY

Table (2). Routing sheet for fabrication of the parts of the Back:

Operation No.	Operation Description	Machine Type	Setup Time	Operation Time	Material
01-01	Sheet Cutting	Laser cutting	30 min	10 min	Al
02-01	Cut to Length Square tubes	Hack Saw	5min	15min	Al
03-01	Cut to Length Pipes	Hack Saw	5min	10min	Al
02-02	Drill Holes in Square tubes	Drill Machine	5min	30min	
03-02	Pipe Bending	Pipe Bending Machine	5min	20min	
04-01	Joining Through Welding	Arc Welding Machine	5min	15min	
05-01	Grinding Welding Beads	Powered Hand Grinder		10min	

Table (3) Routing sheet for fabrication of the parts of the Frame for hands:

Operation No.	Operation Description	Machine Type	Setup Time	Operation Time	Material
02-01	Cut to Length Square tubes	Hack Saw	5	15	Al
03-01	Cut to Length Pipe	Hack Saw	5	15	
03-02	Pipe Bending	Pipe Bending Machine	5	5	
06-01	Round Disc Cutting	Turning	10	10	
04-01	Joining Through Welding	Arc Welding Machine	5	15	
05-01	Grinding Welding Beads	Powered Hand Grinder		10	

Table (4) Routing sheet for fabrication of the parts of the Plate:

Operation No.	Operation Description	Machine Type	Setup Time	Operation Time	Material
01-01	Sheet Cutting	Plasma cutting	20	15	Al

02-01	Hole Drilling in Sheet	Drill Machine	5	15	
03-01	Cut to Length Pipe	Hack Saw	5	20	
06-01	Boring Collar	Lathe Machine	15	15	
04-01	Joining Through Welding	Arc Welding Machine	5	15	
05-01	Grinding Welding Beads	Powered Hand Grinder		10	

Table (5) Routing sheet for fabrication of the parts of the Plate:

Operation No.	Operation Description	Machine Type	Setup Time	Operation Time	Material
03-01	Cut to Length Pipe	Hack Saw	5	15	Al
03-02	Pipe Bending	Pipe Bending Machine	5	5	
04-01	Joining Through Welding	Arc Welding Machine	10	30	
05-01	Grinding Welding Beads	Powered Hand Grinder		10	

Table (6) Routing sheet for fabrication of the parts of the Front wheel Asy.:

Operation No.	Operation Description	Machine Type	Setup Time	Operation Time	Material
01-01	Sheet Cutting	Plasma cutting	10	15	Al
03-01	Cut to Length Pipe	Hack Saw	5	15	
02-01	Drilling hole in Pipe	Drill Machine	10	15	
02-01	Drilling hole in Sheet	Drill Machine	10	30	
07-01	Sheet Bending	Sheeting Bending Machine	5	5	
04-01	Joining Through Welding	Arc Welding Machine	10	30	
05-01	Grinding Welding Beads	Powered Hand Grinder		10	

Table (7) Routing sheet for fabrication of the parts of the Seat:

Operation No.	Operation Description	Machine Type	Setup Time	Operation Time	Material
01-01	Sheet Cutting	Plasma cutting	5	15	
03-01	Cut to Length Pipe	Hack Saw	5	5	
02-01	Drilling hole (Pipe)	Drill Machine	10	30	
07-01	Sheet Bending	Sheeting Bending Machine	5	5	
04-01	Joining Through Welding	Arc Welding Machine	10	30	
05-01	Grinding Welding Beads	Powered Hand Grinder		10	

Table (8). Coordinates of interesting points:

POINT	z-coordinate (in)	y-coordinate (in)
G	1.91102	-5.15157
H	19.885	-5.15157
P	10.4535	8.66102
A	3.28839	5.66102
B	6.02874	3.44843
C	16.4508	7.21102
D	1.58917	-4.02008

E	11.1829	-0.532283
F	13.3669	0.158465

Table (9). Labor costs.

Operation description	Piece	Labor cost
Sheet Cutting By laser cutting tool	Back	350 SR
Sheet Bending By Sheeting Bending Machine	Front wheel supporter, Seat	115 SR
Cutting Square tubes to Length by Hack Saw	Back , Frame for hands	150SR
Cut to Length Pipes by Hack Saw	Back , Frame for hands , Plate , Front wheels frame , Front wheel supporter, Seat	225SR
Drill Holes By Drill Machine	Back , Plate , Front wheel supporter, Seat	75SR
Pipe Bending By Pipe Bending Machine	Back , Frame for hands , Front wheels frame	115 SR
Joining Through Welding By Arc Welding Machine	Back , Frame for hands , Plate , Front wheels frame , Front wheel supporter, Seat	265 SR
Grinding Welding Beads By Powered Hand Grinder	Back , Frame for hands , Plate , Front wheels frame , Front wheel supporter, Seat	225SR
Screws Installation	Back , Frame for hands , Plate , Front wheels frame , Front wheel supporter	–
Sheet Cutting By Plasma cutting machine	Plate , Front wheel supporter, Seat	350SR
Round Disc Cutting	Frame for hands	300SR
Boring Collar By Lathe Machine	Plate	150SR
Painting the surface	Back , Frame for hands , Plate , Front wheels frame , Front wheel supporter, Seat	115SR
Padding the seat And back	Back , Seat	100SR
Seat and back fabric seamstress	Back , Seat	100SR

Assembling	Back , Frame for hands , Plate , Front wheels frame , Front wheel supporter, Seat , Battery , Servo motors, DC motor , Controller , wires	600SR
Connecting Servo motors and DC motor with battery and controller		750SR
Total		4000SR

Table (10). Expanded Bill of Materials.

Piece No	Material	QTY	Buy/make
1	Wheels	2	Buy
2	Battery	1	Buy
3	Battery charger	1	Buy
4	Gears	1 box	Buy
5	Front wheels	2	Buy
6	Servo Motors	1	Buy
7	DC Motor	1	Buy
8	Controller	1	Buy
9	Driving shaft	1	Buy
10	Wires	100 inch	Buy
11	Screws	22	Buy
12	Seat and back nylon cover	1	Buy
13	Seat and back fabric	1	Buy
14	Seat and back liner	1	Buy
15	Plastic hand Frame	1	Buy
16	Paint	1	Buy
17	Back	1	Make
18	Plate	1	Make
19	Frame for hands	1	Make

20	Seat	1	Make
21	Frame for front wheels	1	Make
22	Front wheels Supporter	2	Make

Table (11). Estimated total cost of the final product.

Total Estimate Price	
Total costs of raw materials	1380SR
Total costs of other materials	2682SR
Total labor costs	1000SR
Total costs of project	5062SR

Section	Feature to be tested	Specification reference	Testing method or procedure	Pass/fail
1	Dimensions	5.1	Measure the length, height, width of the folded wheelchair	
2	Motor	5.2	Make sure it runs properly and with the required speed	
3	Breaking system	5.3	Make sure it stops immediately and safely	
3.1	Breaking system comfort	5.3	Make sure the wheelchair stops without annoying the user	
4	Power and battery	5.4	Calculate how much time the battery lasts for	
4.1	Battery charging	5.4	Calculate the time required to fully charge the battery	
5	Stress and forces	5.5	Calculate the stress on each element and compare them with the design forces	
5.1	On the back	5.5	Calculate the stress on the back	
5.2	On the seat	5.5	Calculate the stress on the seat	
5.3	On the wheels	5.5	Calculate the stress on the wheels	
6	Circuits and connections	5.6	Make sure the circuits are connected	
6.1	Motor/battery	5.6	Testing the connection between the motor and the battery	
6.2	Motor wheels	5.6	Testing the connection between the motor and the wheels	
6.3	Maneuverability system	5.6	Testing the connection between the motor and the maneuverability system	

Appendix C: Actual Design and Modifications

Figure Seat frame

Figure Back Rest Frame

Figure Front Wheels Frame.

Figure Assembled form of the Front Wheels frame with the Back by means of the main Plate.

Figure The linking member between the Rear Wheel Support and the Front Wheels Frame.

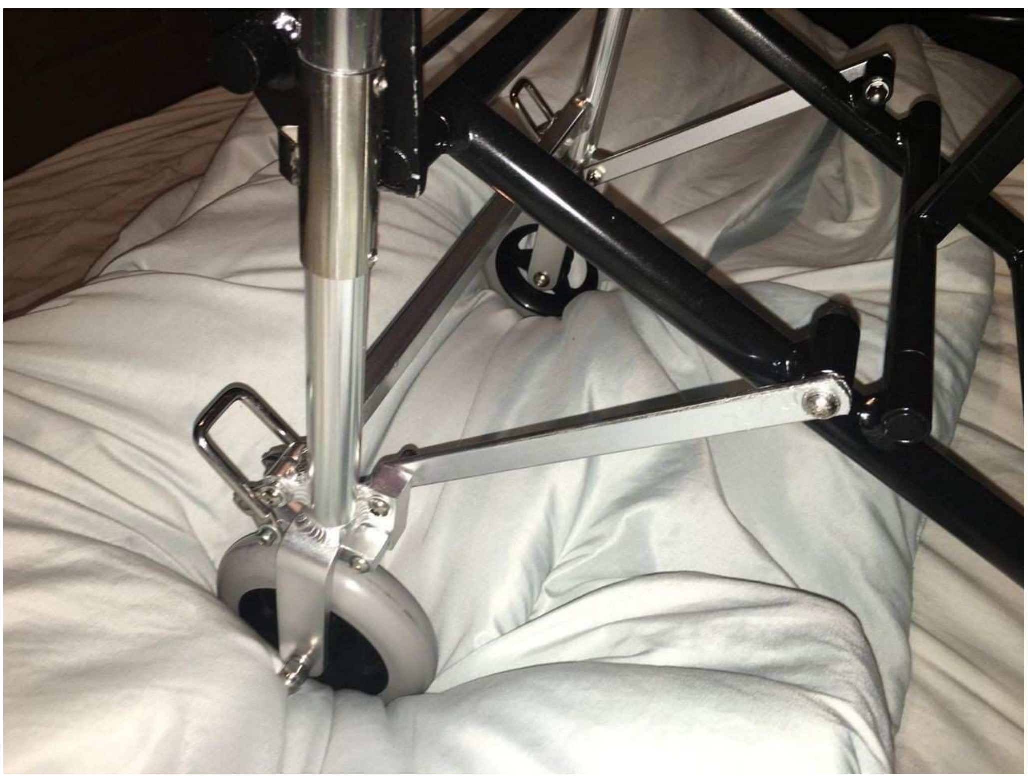


Figure The Assembled form of the Rear wheels support and their link to the Front Wheels Frame by the linking member and its Cylinder.

Figure The Seat Support and its connection with the Front Wheels Frame.

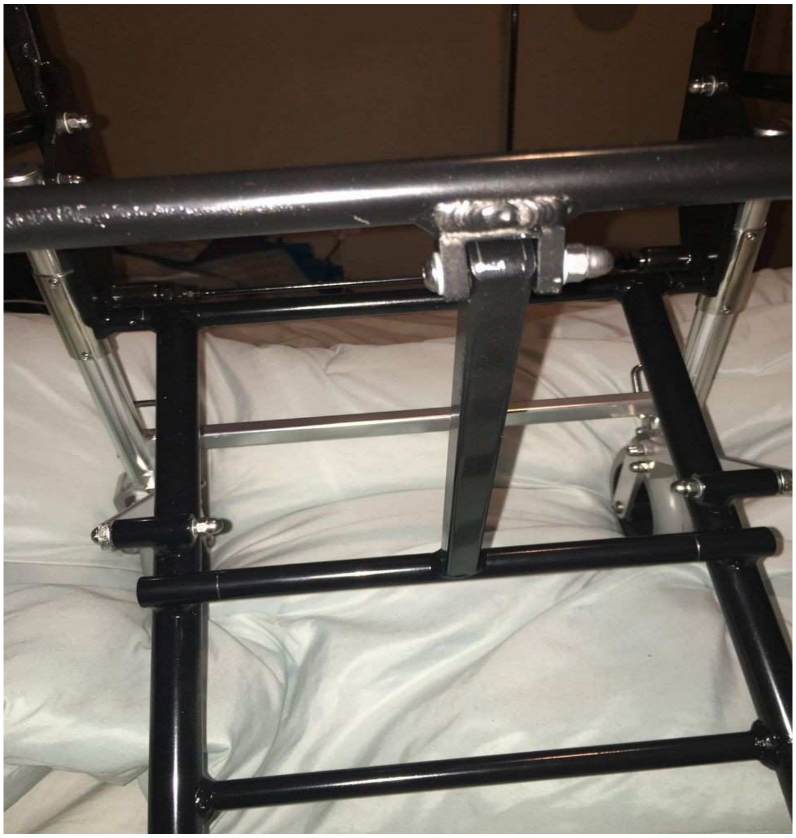


Figure The assembled form of the Seat Support and its connection to the Front Wheels Frame using the Rotation Cylinders.

Figure Rotation Cylinders.

Figure Rotation Cylinders.

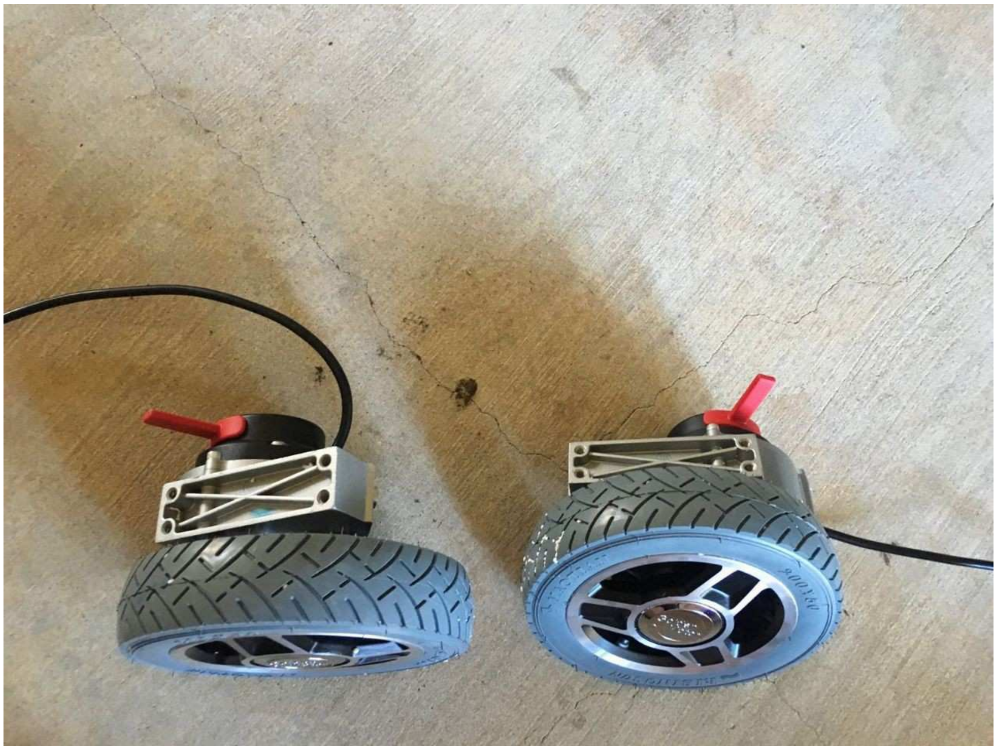


Figure Rear Wheels.

Figure Rear Wheels with their Motors

Figure Additional Supporting wheels used for dragging the Wheelchair when in folded position.

Figure Battry

Figure Battery Charger.

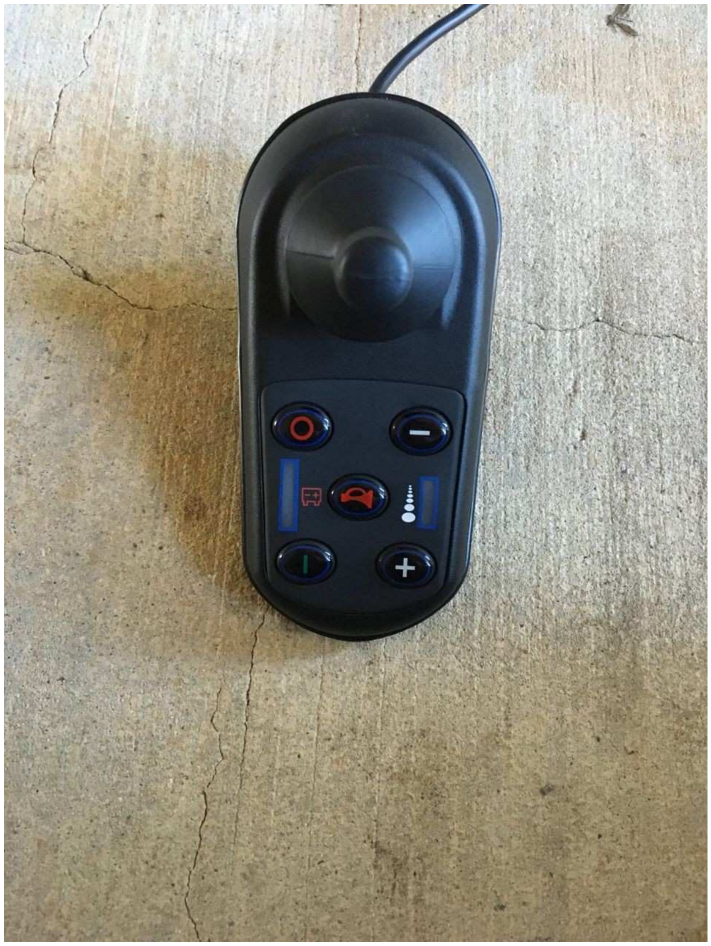


Figure Controller Joystick

Figure Accessories (Anti-Skid Buttons for the Back Supporter to prevent slipping in the case of accidents).

Figure Accessories (Rubber Handles).

Figure Battery and controller bag

9 References

1. Americans with disabilities act. (n.d.). From http://www.ada.gov/

2. ISO - International Organization for Standardization. (n.d.). From http://www.iso.org/iso/home.html

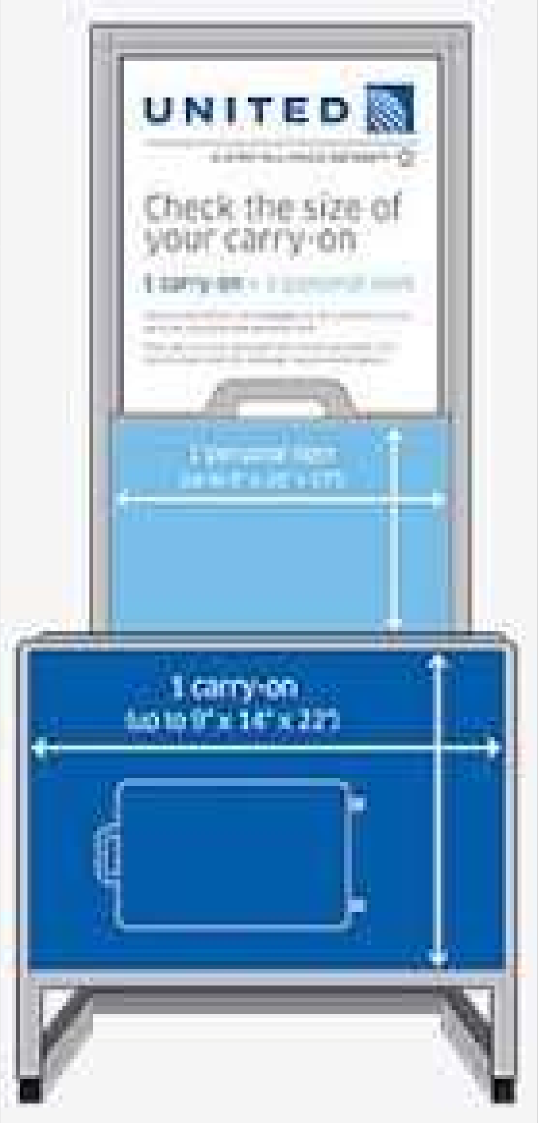
3. Satpathy, J. (2014, May). DESIGN OF MOTORISED WHEELCHAIR. DESIGN OF MOTORISED WHEELCHAIR.

4. A. (n.d.). History Of The Wheelchair. Retrieved October 30, 2016, from http://www.mobilityscooters.co.nz/history/wheelchairs

Presentation Outline

Purpose:

- An electric foldable wheelchair.
- Can fit in carry-on bag inside a plane.
- Cater to children, amputates and elderly.



Objectives:

- The objective of the project is to design, analyze, and build an electrical foldable wheelchair that can fit in carry-on bag size inside a plane.

Functional Requirements:

- Low weight and small volume.
- Wheelchair will be foldable.
- Emergency braking system.
- Rechargeable powered drives.

Design Specification:

- The conventional wheels will be used in this design then it will restrict the foldable size requirement of the Project.
- In unfolded condition, the chair will acquire the enough size to fit ergonomic shape that will be comfortable to use by patient. As shown below;

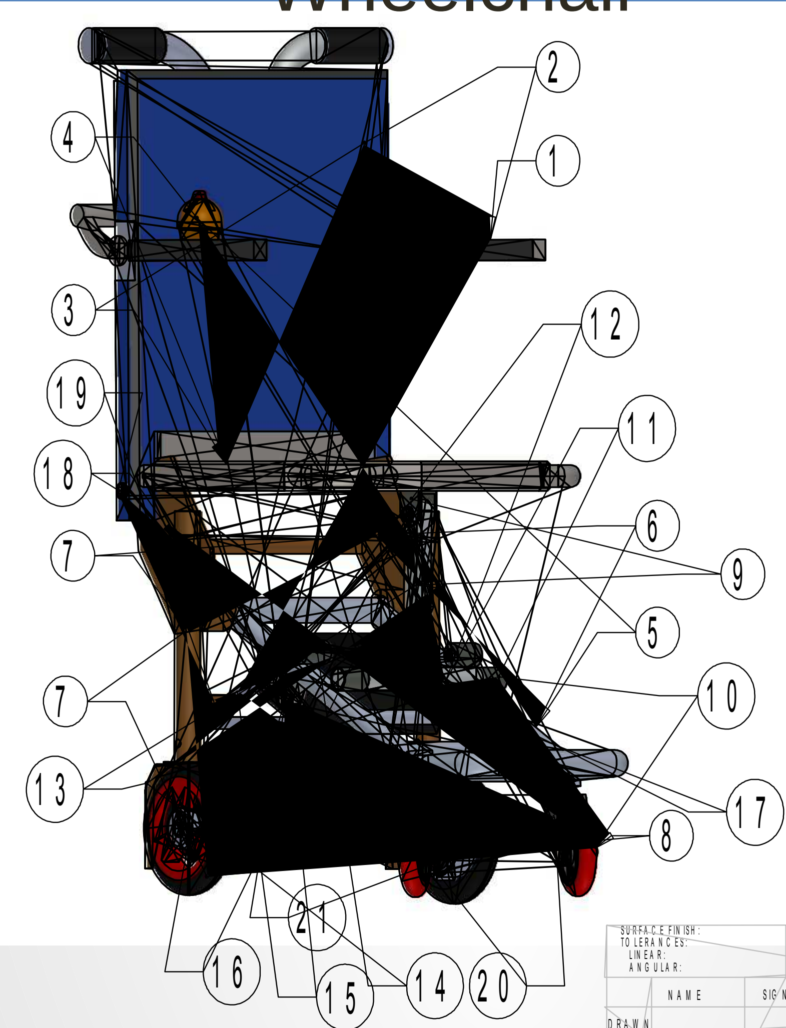
Design Specification:

- The device must be able to drive the wheelchair forward, backward, right, and left.
- The device must be able to control the wheelchair by a joystick.
- The maximum speed for the wheelchair is 8 km/h.
- The device has a maximum charging time of 6-8 hours.
- Front wheels will be free rotational.

Design Specification:

- Ratchet Mechanism will be used on both the rear wheels of the wheelchair for braking purposes on slopes.
- Power not exceed 180 W.
- Electric drive battery required.
- Lithium battery of 24V and 10AH will be used.
- To turn the wheelchair, the front rear wheels will be turned with help of motors and controlled by the throttle that will be manipulated by the hand movement of the patient.

Configuration of Wheelchair



ITEM No.	NAME OF PART	NUMBER OF PART
1	Fram for hands	1
2	Back	1
3	Seat	1
4	Control arm	1
5	Fram front wheel	1
6	Plate	1
7	Back wheel with motor	2
8	Front wheel	2
9	Frame front wheels supporter	1
10	Rotation cylinder	2
11	Rotation cylinder piece	1
12	Fixation link	1
13	Back support	2
14	Rotation cylinder2	2
15	Link (leg , frame)	2
16	Fram front wheel link	2
17	Lithium battarey	1
18	DIN 1445 - 8x50 St-N	2
19	0.3125-clevis pin	2
20	Set front wheel	2
21	Heavy hex flange screw, M8 x 1.25 x 12 - - 12N	4

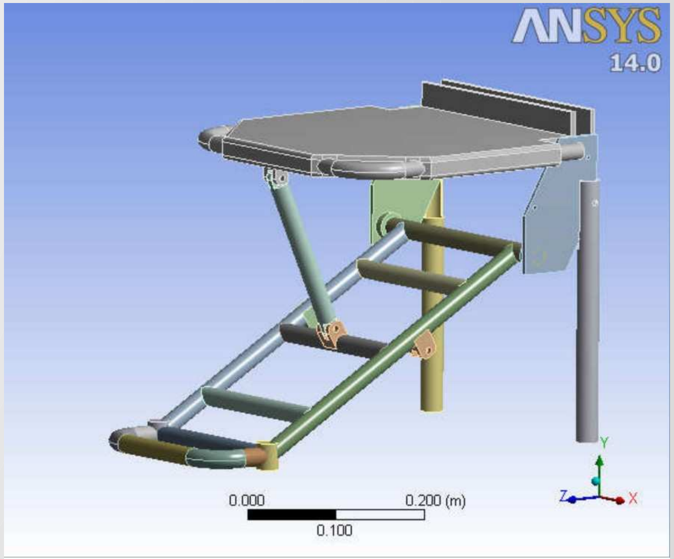
SURFACE FINISH:
TOLERANCES:
LINEAR:
ANGULAR:
FINISH:
DEBUR AND BREAK SHARP EDGES
DO NOT SCALE DRAWING
REVISION

	NAME	SIGNATURE	DATE
DRAWN			
CHK'D			
APPV'D			
MFG			
Q.A			

TITLE:
Assembly Drawing
Final project
MATERIAL:
A4
WEIGHT:
SCALE:1:6
SHEET 1 OF 1

Structure integrally:

- A FEA analysis has already been done on the wheelchair using ANSYS. For further testing following procedure will be followed:
- 1-Testing of Fabricated Components.
- 2-Testing for Fasteners.
- 3-Testing after Assembly.



Fabrication:






un-folded wheelchair condition:

Folded wheelchair condition:

Video:

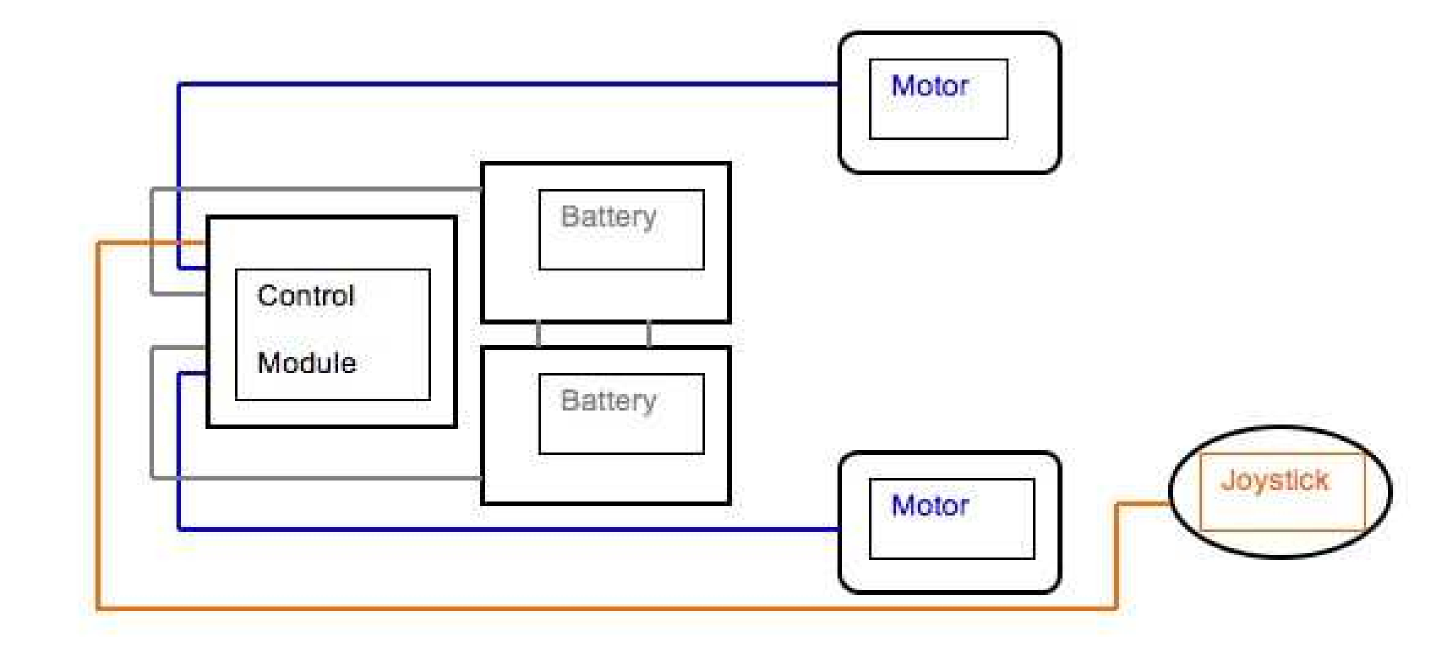
Electrical Kit:

Parts	Description
2 Gear-motors	180W x 24V
Battery and charger	24V 10AH
Joystick/controller	Brushless Controller



Electrical Testing:

Testing of Motors:
Motors speed and torques tested on both dry run and loaded condition before installation
Testing of Battery:
Battery tested on dry run and loaded conditions from full charge to discharge after installation.



Electrical Testing before assembly:

Electrical Testing:

Compliance Matrix			
Section	Feature to be tested	Testing method or procedure	Pass/Fail
1	Motor	Make sure it runs properly and with the required speed	PASS
2	Breaking system	Make sure it stops immediately and safely	PASS
2.1	Breaking system comfort	Make sure the wheelchair stops without annoying the user	PASS
3	Power and battery	Calculate how much time the battery lasts for	PASS
3.1	Battery charging	Calculate the time required to fully charge the battery	PASS
4	Circuits and connections	Make sure the circuits are connected	PASS
4.1	Motor/battery	Testing the connection between the motor and the battery	PASS
4.2	Motor wheels	Testing the connection between the motor and the wheels	PASS

Speed testing:

Speed test					
Test	Distance (m)	Time (sec)	Speed m/sec	Pass/fail
1	100	44.2	2.26	Pass
2	100	46.2	2.16	Pass
3	100	45.5	2.19	Pass
avg	100	45.3	2.21	Pass

Estimated Cost:

Total costs of Raw materials	**$368**
Total costs of other materials	$815
Total costs of Staff	$267,450
Total cost of the project	$268,633

Conclusion:

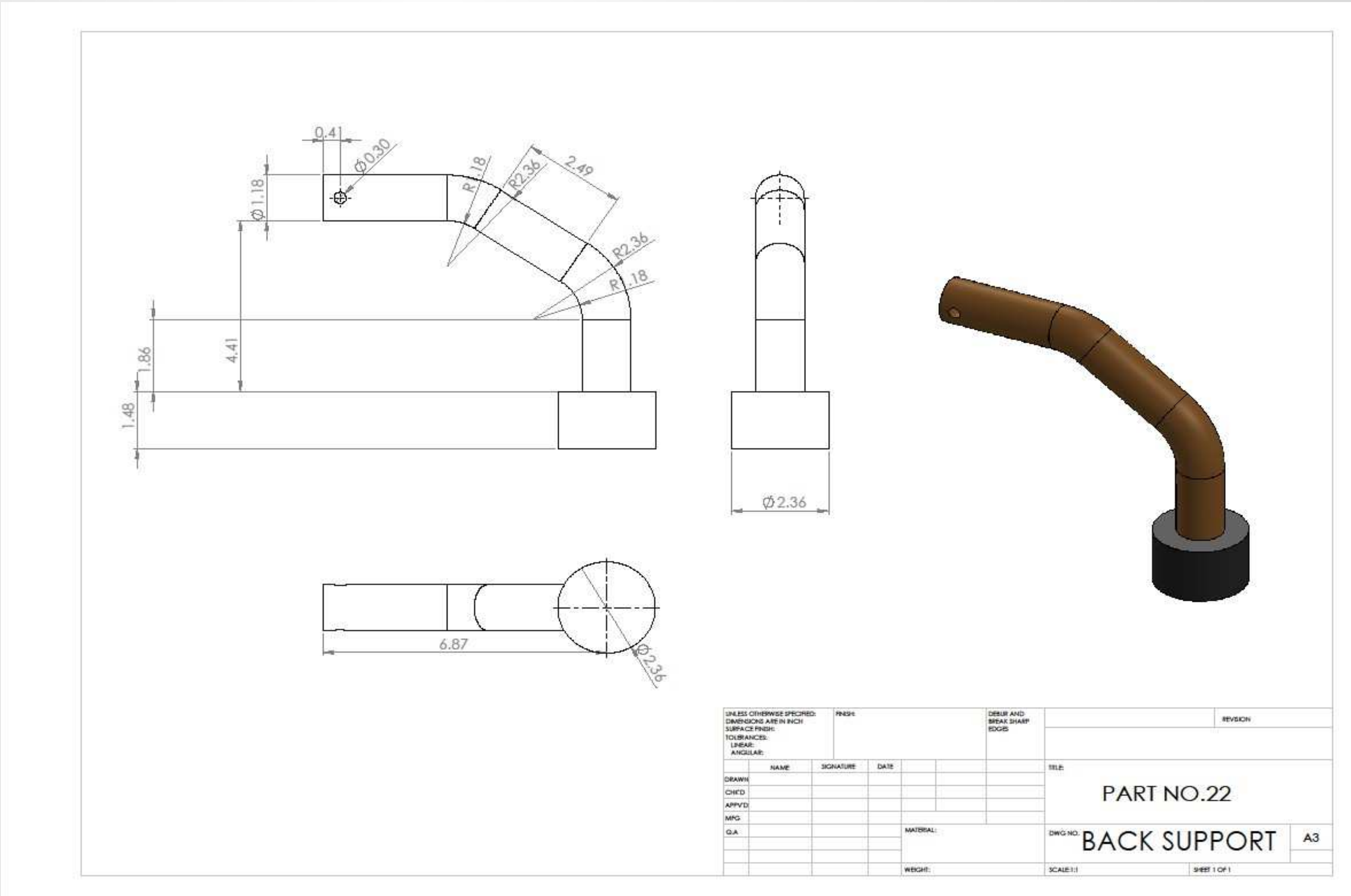
- ✓ This project is to design, test , build an electrical foldable wheelchair that can fit in carry-on bag size.
- ✓ Team want to thank :

Disability people who helped us do this project by giving us enough information to make this project doable.

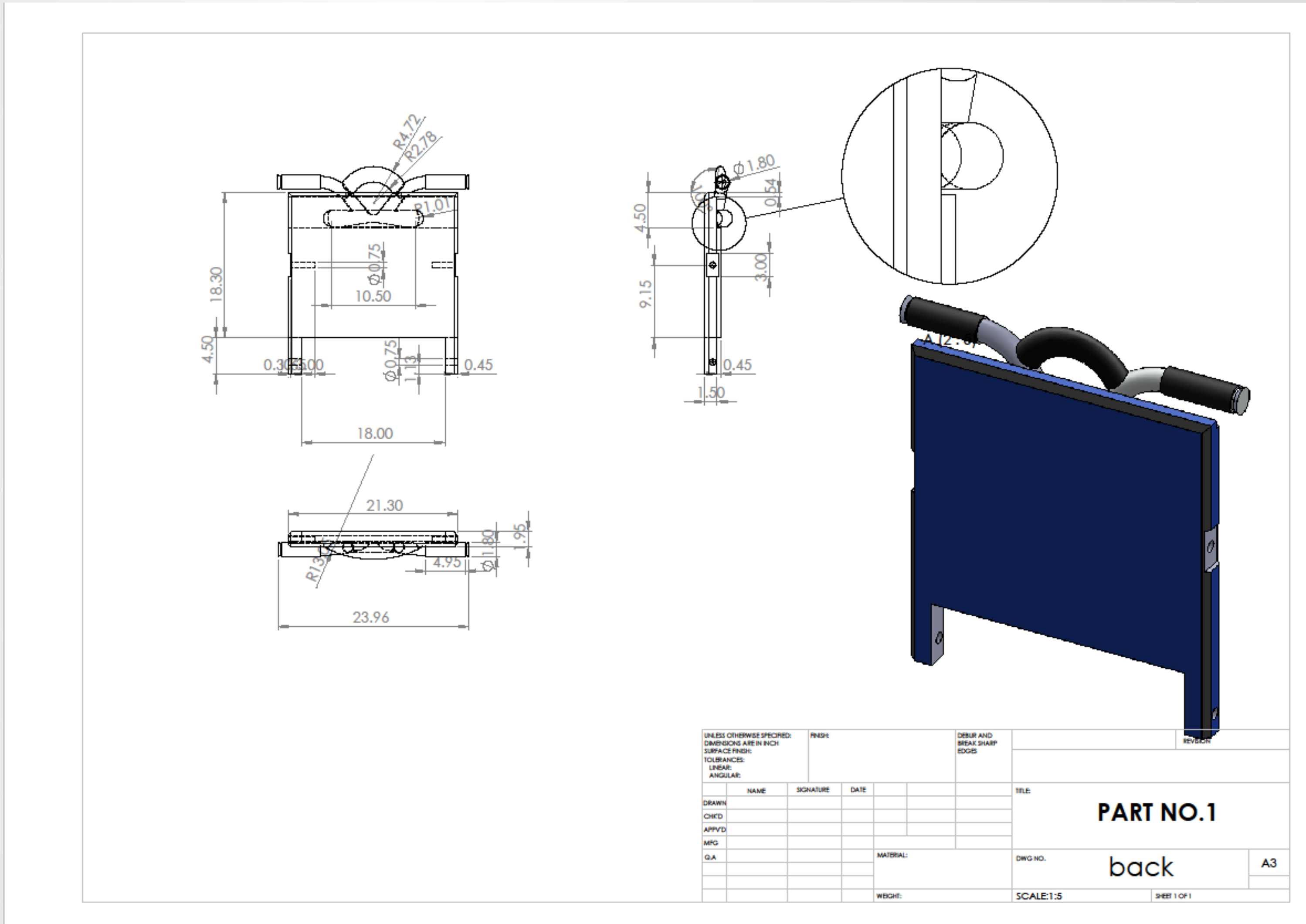
Questions?

Fabrication Plan:

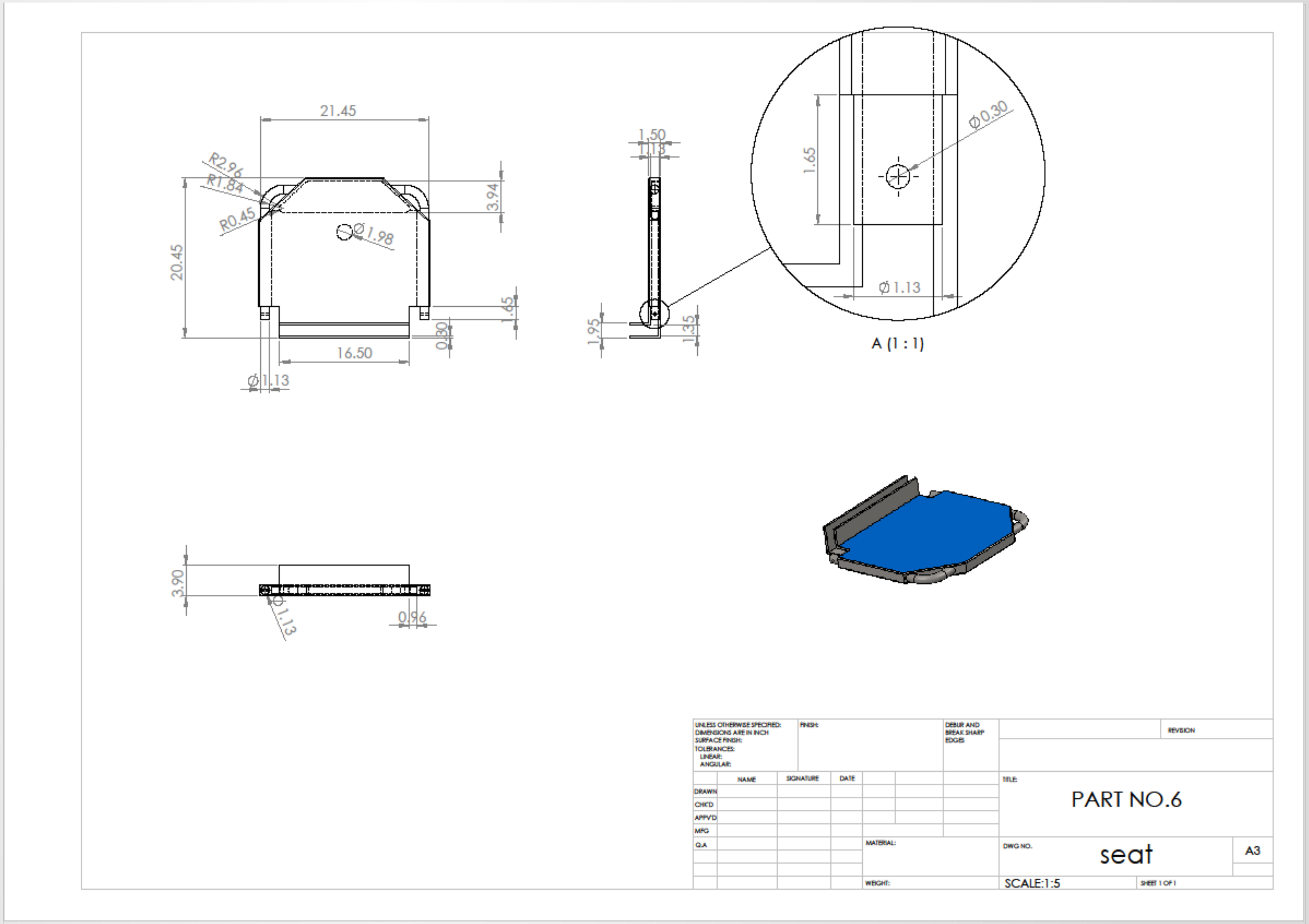
Back Support:



Back:

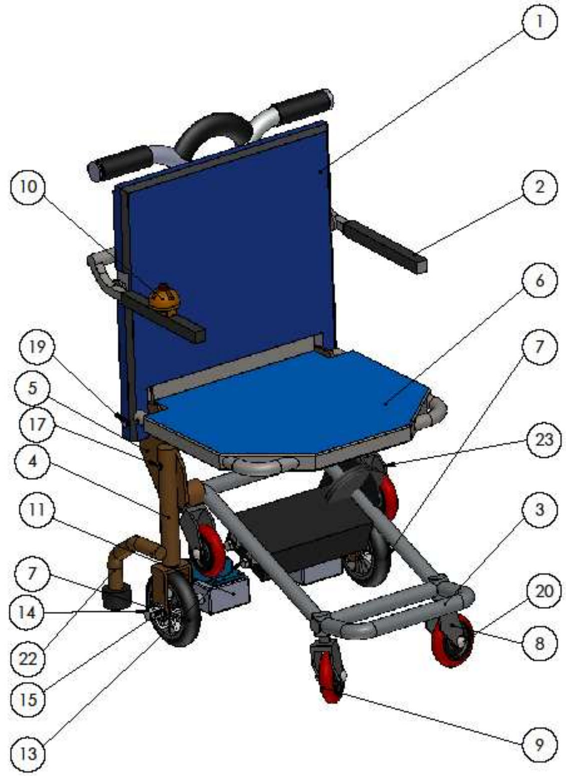

R4.72
R2.78
R1.01
Ø1.80
18.30
Ø0.75
10.50
4.50
0.30
5.00
Ø0.75
1.13
0.45
18.00
9.15
3.00
0.54
1.50
21.30
1.80
1.95
4.95
23.96
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCH
SURFACE FINISH:
TOLERANCES:
LINEAR:
ANGULAR:
FINISH:
DEBUR AND BREAK SHARP EDGES
REVISION
NAME
SIGNATURE
DATE
DRAWN
CHK'D
APPV'D
MFG
Q.A
MATERIAL:
WEIGHT:
TITLE:
PART NO.1
DWG NO.
back
A3
SCALE:1:5
SHEET 1 OF 1

Seat:



21.45
R2.96
R1.84
R0.45
Ø1.98
3.94
20.45
1.65
0.30
16.50
Ø1.13
1.50
1.13
1.95
1.35
Ø0.30
1.65
Ø1.13
A (1 : 1)
3.90
Ø1.13
0.96
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCH
SURFACE FINISH:
TOLERANCES:
LINEAR:
ANGULAR:
FINISH:
DEBUR AND BREAK SHARP EDGES
REVISION
NAME
SIGNATURE
DATE
DRAWN
CHK'D
APPV'D
MFG
Q.A
MATERIAL:
WEIGHT:
TITLE:
PART NO.6
DWG NO.
seat
A3
SCALE:1:5
SHEET 1 OF 1

Assembly:



ITEM NO.	PART NUMBER	DESCRIPTION	explode/QTY.
1	back		1
2	fram for hands		1
3	frame front wheels		1
4	front wheel support		2
5	plate		1
6	seat		1
7	wheel		2
8	set wheel 2		2
9	wheel2		2
10	control arm		1
11	motor		2
13	B18.2.3.9M - Heavy hex flange screw, M8 x 1.25 x 12 --12N		4
14	B18.2.3.5M - Hex bolt M10 x 1.5 x 60 --26N		2
15	AM-M12-N		2
16	ASME B18.8.2 - 0.1877x2		2
17	0.3125-Clevis Pin		1
18	0.25-Clevis Pin		1
19	DIN 1445-8x50-St-N		2
20	DIN 124-10x48-St-A-32		4
21	back support 1		1
22	back support		2
23	SET WHELL3		2

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCH SURFACE FINISH: TOLERANCES: LINEAR: ANGULAR:

FINISH: DEBUR AND BREAK SHARP EDGES

1 : 5 REVISION

NAME SIGNATURE DATE

DRAWN
CHK'D
APPV'D
MFG
Q.A

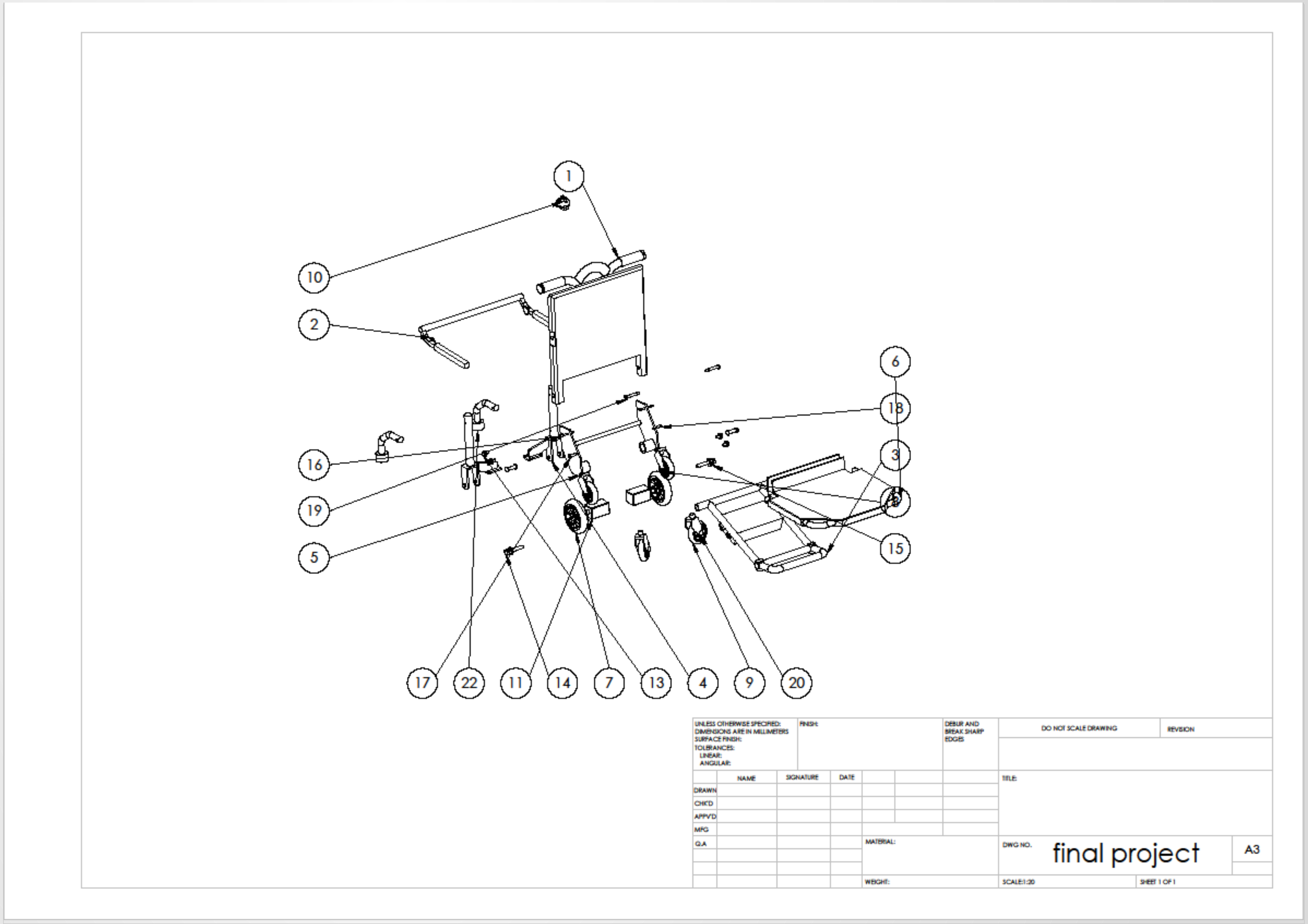
TITLE: Assemply drw

MATERIAL:

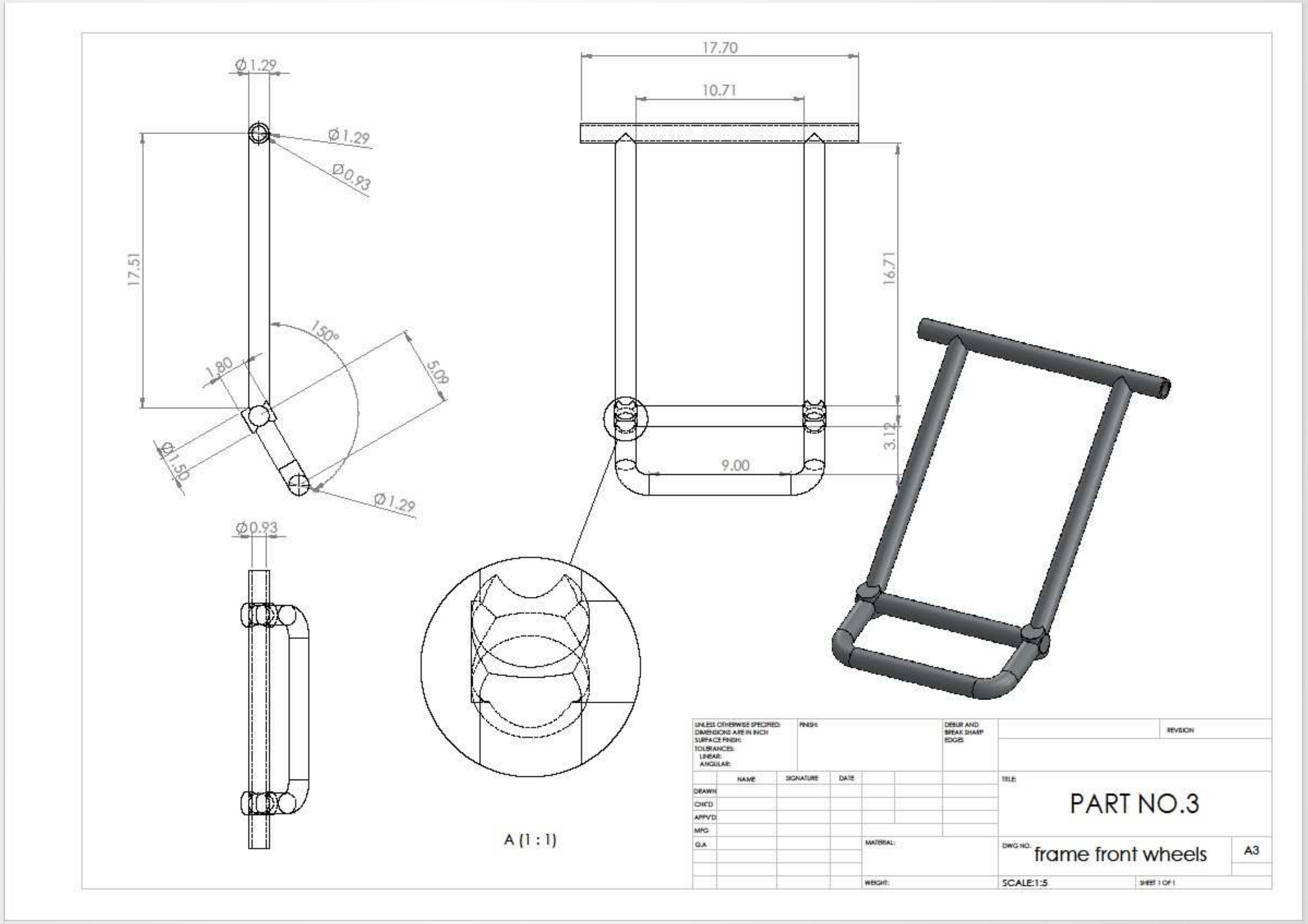
DWG NO. final project A3

WEIGHT: SCALE1:5 SHEET 1 OF 1

Exploded view:



Frame for wheels:



Frame for hands:

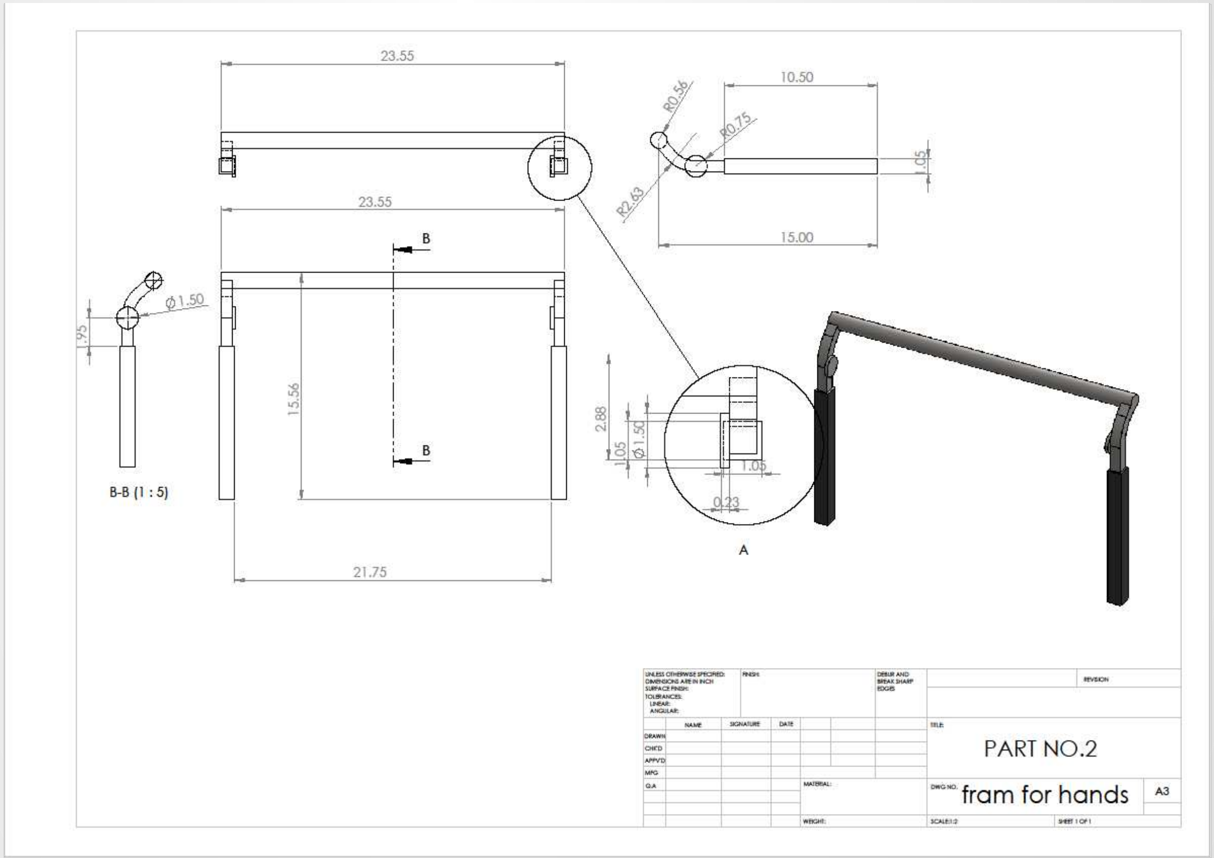
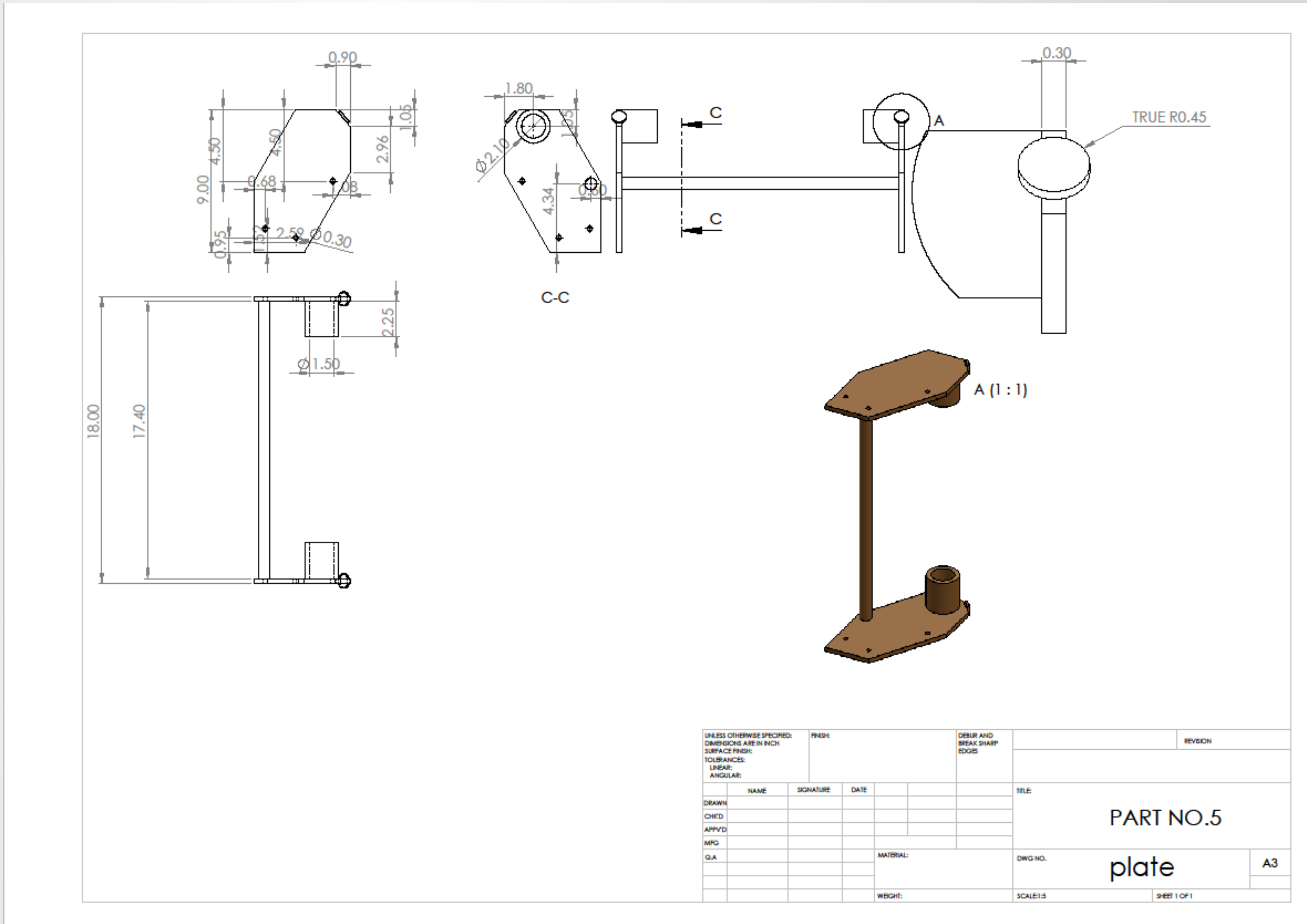
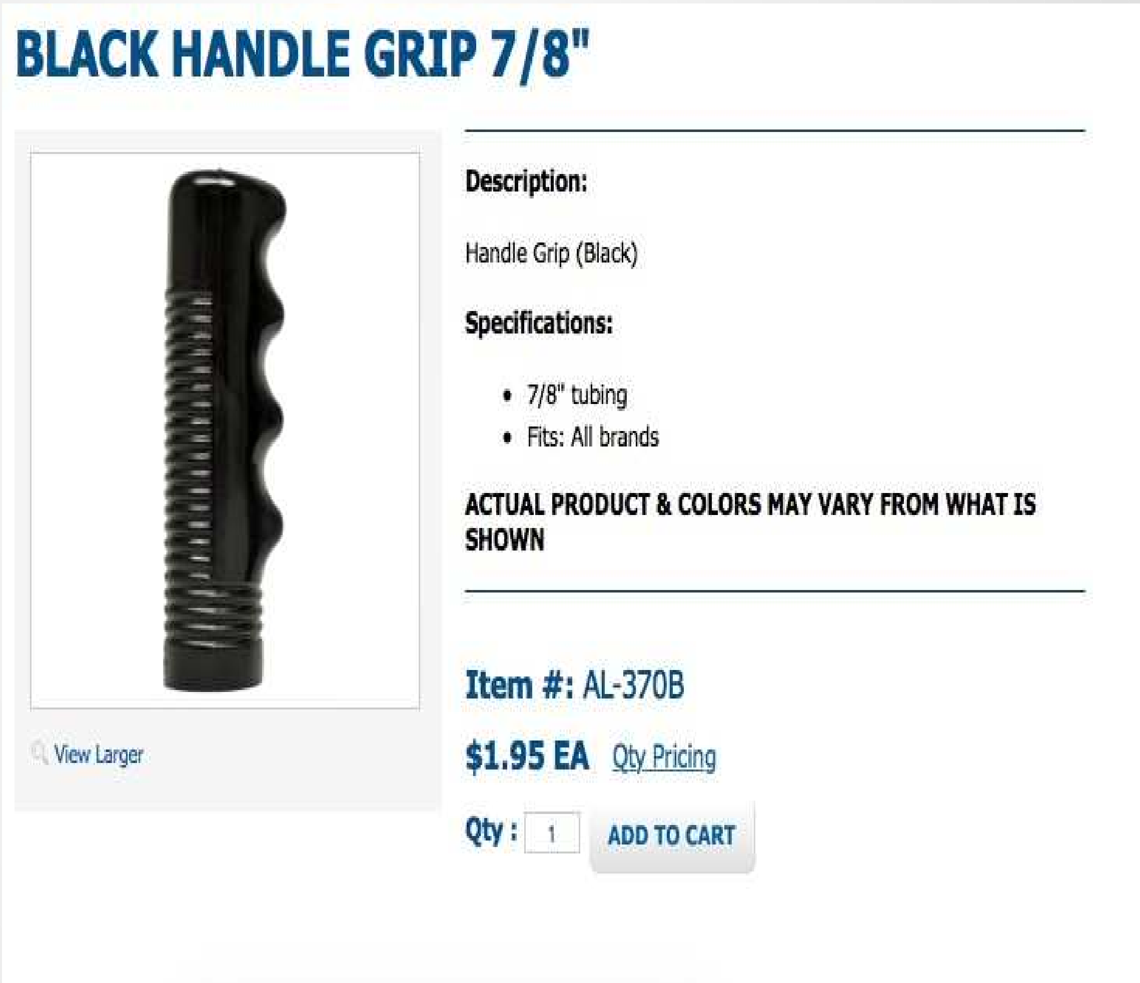


Plate:



C-C
A (1 : 1)
TRUE R0.45
0.90
1.80
0.30
1.05
2.96
4.50
9.00
0.68
1.08
0.95
2.58
Ø0.30
Ø2.10
4.34
0.80
2.25
Ø1.50
18.00
17.40
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCH
SURFACE FINISH:
TOLERANCES:
LINEAR:
ANGULAR:
FINISH:
DEBUR AND BREAK SHARP EDGES
REVISION
NAME
SIGNATURE
DATE
DRAWN
CHK'D
APPV'D
MFG
Q.A
TITLE:
PART NO.5
MATERIAL:
DWG NO.
plate
A3
WEIGHT:
SCALE:1:5
SHEET 1 OF 1

Handle grip:


BLACK HANDLE GRIP 7/8"
View Larger
Description:
Handle Grip (Black)
Specifications:
7/8" tubing
Fits: All brands
ACTUAL PRODUCT & COLORS MAY VARY FROM WHAT IS SHOWN
Item #: AL-370B
$1.95 EA
Qty Pricing
Qty : 1
ADD TO CART

Seat Testing:

Test for the seat		
Force applied (lb)	**Max load (lb)**	**Pass/fail**
244	250	PASS