A PROJECT REPORT

ON

"DESIGN AND FABRICATION OF 3 IN 1 TRANSFORMING WHEELCHAIR"

Submitted by

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In partial fulfilment for the award of the Degree

Of

BACHELOR OF ENGINEERING

IN

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UNDER THE GUIDANCE

Of

Prof. Atul Meshram

DEPARTMENT OF MECHANICAL ENGINEERING

ANJUMAN-I-ISLAM

KALSEKAR TECHNICAL CAMPUS NEW PANVEL,

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CERTIFICATE

This is to certify that the project entitled

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To the Kalsekar Technical Campus, New Panvel is a record of bonafide work carried out by him under our supervision and guidance, for partial fulfillment of the requirements for the award of the Degree of Bachelor of Engineering in Mechanical Engineering as prescribed by **University Of Mumbai**, is approved.

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APPROVAL OF DISSERTATION

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(Internal Examiner) (External Examiner)

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Date: __________

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ABSTRACT

It is inevitable for any country to have people with disabilities, especially arthritis patients. The most commonly used devices for disabled people are wheelchairs. What's more, the life quality of disabled people and patients has caught attention by society. Modernized wheelchair has become a popular engineering challenge for decades.

We aimed to design a new mechanical system in wheelchair to help people stand up, sitting and lying down with help of single actuator. This mechanism should be safer, simpler in structure, less power consuming and more economic.

The wheelchair which we are going to design may help people with disability to surge self-esteem; reach objects placed high, deliver speech on podium, sit & sleep with comfort. By the way, it's boring for a person to sit for long time.

If somebody wants to buy standing wheelchair, he or she do not need to buy a whole wheelchair, only buy four-bar mechanism structure, then install it to his or her own wheelchair with some adjusments and can achieve three positions . That wheelchair can achieve the same goal to stand up, sit and sleep. So it will make the wheelchair cheaper.

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Chapter 1: Introduction

Traditionally, a wheelchair is a wheeled mobility device in which the user sits. The device is either propelled manually (to turning the wheels by hand) or via various automated systems. Wheelchairs are used by people for whom walking is difficult or impossible due to illness (physiological or physical), injury or disability.

Wheelchairs play irreplaceable role in aiding people for few decades. Therefore, the upgrade and refreshment of wheelchair function and mechanical structure will be a priority for community and welfare institution. Wheelchair has a variety range of styles in current market. Aluminium, steel and lightweight solid are the common materials in manufacturing. It can also be classified by functions: manually operable wheelchairs and Electrical controlling wheelchairs. Nowadays, 3 in 1 TRANSFORMING wheelchair is developed as a new kind of wheelchair. If the patient wants to reach a higher position of even deliver a speech at podium and sleep, he or she will be willing to form all the three process. At this time, transforming wheelchair will help him or her to accomplish this goal.

We searched about most common types of standing wheelchair on Internet. We found most pure mechanical wheelchair require arm force when achieving all the three motion (in market only two positions available). Compared to this kind of wheelchair, electrical wheelchair is more advanced. We are designing this wheelchair to make the disabled person comfortable. The wheelchair we designed will use less electrical energy to help people standing, sleeping & sitting nevertheless it will be as convenient as electric wheelchair

1.1Problem statement, objectives and main contribution

The objective of this project is to design a semi-automatic mechanical wheelchair. This wheelchair helps those who are elder, weak or patients in rehabilitation.

The wheelchair we designed will overcome difficulties as follows.

The first is designing structures that can perform a natural human standing, sleeping & sitting behaviour.

Main contribution of this project is to design a new mechanical structure. The wheelchair can reform automatically and support the costumer standing up, sleeping & sitting. The mechanism position fits the human standing posture, sleeping position for the rest & sitting position. This mechanism can be removed and can be easily fix to any wheelchair base. This kind of wheelchair will use less electrical power compared to traditional electrical wheelchair, it can save energy and work stable as well. Components we used are available in the market.

Chapter 2: Literature survey

2.1 Census of India, Data on disability

Increase in Disabled Population:

As per report by Census of India, Data on Disability, Every decade there is a significant rise in disability population which is shown in Fig.2.1. Total disabled population in india to total population of india in 2001 was 2.13% which riseto 2.21% in 2011.

Percentage of Disabled to total population India, 2011			
Residence	Persons	Males	Females
Total	2.21	2.41	2.01
Rural	2.24	2.43	2.03
Urban	2.17	2.34	1.98

Percentage of Disabled to total population India, 2001			
Residence	Persons	Males	Females
Total	2.13	2.37	1.87
Rural	2.21	2.47	1.93
Urban	1.93	2.12	1.71

Figure 2.3 comparison of disabled population in 2011 and 2001

Disability Population in Movement :

Fig. 2.2 and 2.3 shows various disability population. The data shows Disability in Movement is higher compared to other disability. Of total disability, disability in movement is 20.3%.

Disabled Population by Type of Disability
India : 2011

Type of Disability	Persons	Males	Females
Total	**26,810,557**	**14,986,202**	**11,824,355**
In Seeing	5,032,463	2,638,516	2,393,947
In Hearing	5,071,007	2,677,544	2,393,463
In Speech	1,998,535	1,122,896	875,639
In Movement	5,436,604	3,370,374	2,066,230
Mental Retardation	1,505,624	870,708	634,916
Mental Illness	722,826	415,732	307,094
Any Other	4,927,011	2,727,828	2,199,183
Multiple Disability	2,116,487	1,162,604	953,883

Figure 4.2 Disability Population by Type of disability

(%)

Proportion of Disabled Population by Type of Disability
India : 2011

Type of Disability	Persons	Males	Females
Total	100.0	100.0	100.0
In Seeing	18.8	17.6	20.2
In Hearing	18.9	17.9	20.2
In Speech	7.5	7.5	7.4
In Movement	20.3	22.5	17.5
Mental Retardation	5.6	5.8	5.4
Mental Illness	2.7	2.8	2.6
Any Other	18.4	18.2	18.6
Multiple Disability	7.9	7.8	8.1

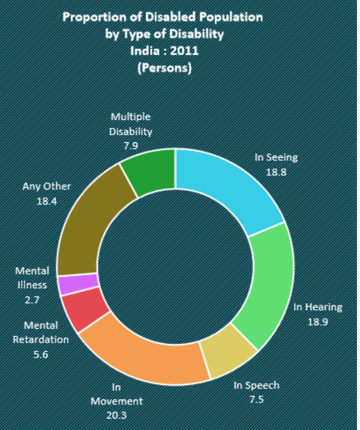

Figure 2.3 Proportion of Disabled Population by Type of Disability India :2011 [8]

Disability by Type and Gender :

The graph shows the comparison of disability by sex. From this data, disability in seeing and hearing is more among females, whereas disability in movement is more among males.

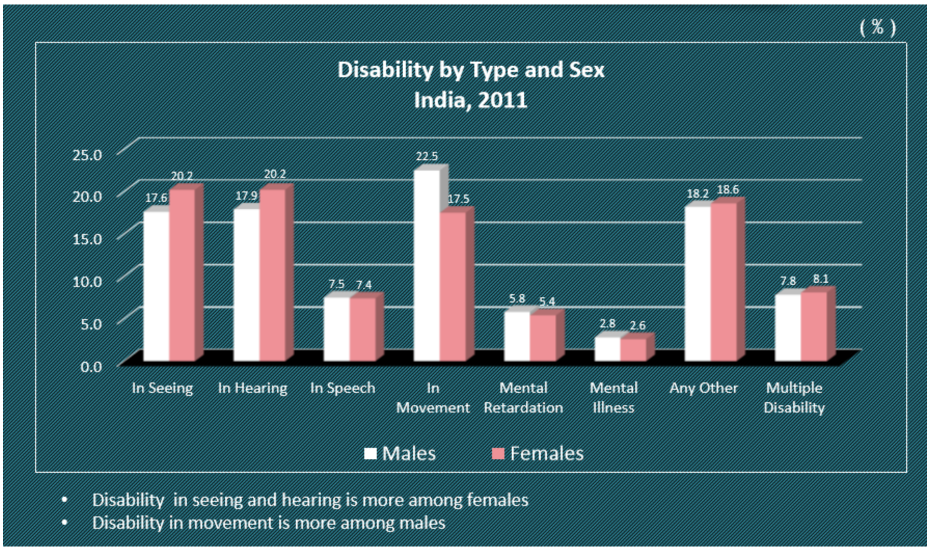

Figure 2.4 Disability by Type and Sex India, 2011. [8]

2.2 Body weight distribution

The body weight distribution of two Michigan data and Leipzig data are given. These data shows similar body weight distribution of weight of different body. This data is useful in Analysis using weight acting on seat, back rest and leg rest.

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TABLE 4

Mean weights of male cadaver segments and ratio to total body weight

	Michigan data (Dempster)		Leipzig data (Braune and Fischer)	
	Mean weights (gm)	% of Total	Mean weights (gm)	% of Total
Total body weight	61190 ±8137 (7)	100	58895 (5)	
Head and trunk	34637 ±5607 (18)	56.34 ±2.45 (6)	30824 (5)	52.21 ±2.97(5)
Head and trunk minus shoulders	28077 ±3994 (18)	46.02 ±2.239(5)		
Head and neck	5119 ± 838 (16)	7.92 ±0.85 (7)		
Shoulders	3401 ± 843 (34)	5.27 ±0.546(14)		
Thorax	7669 ±2270 (17)	10.97 ±1.521(7)		
Abdomino-pelvic headless trunk	16318 ±2505 (18)	26.39 ±2.908(7)		
Arm	1636 ± 350 (42)	2.64 ±0.294(14)	2017 ±406 (22)	3.167±0.27 (10)
Forearm	947 ± 199 (42)	1.531±0.166(14)	1342 ±242 (18)	2.087±0.245(6)
Hand	378.3± 71.7(42)	0.612±0.058(14)	536.1± 84.4(18)	0.833±0.045(6)
Thigh	609.6± 985 (41)	10.008±1.197(14)	6632 ±783 (22)	10.924±0.769(10)
Shank	2852 ± 695 (41)	4.612±0.534(14)	2924 ±379 (22)	4.680±0.353(10)
Foot	884 ± 178 (41)	1.431±0.142(14)	1072 ±106 (22)	1.765±0.194(10)

Figure 2.5 Body weight distribution.

The upper body includes head and trunk, two arms, two forearm, two hands. The lower body include two thighs, two shanks, two foots. According the data in the table we can calculate.

Mass of upper body = 66%

Mass of thigh link = 20%

Mass of shank link and foot link = 13%

We assume the weight of person is 100 kg.

The force of upper body F = 1000 N * 66% = 660 N

The force of thigh link F= 1000 * 20%= 200 N

The force of shank link and foot link F = 1000 * 13% = 130 N

Chapter 3: Fabrication of Prototype

A prototype of wheelchair working on two actuator is made with wooden structure and all the three positions i.e., sitting, sleeping and standing were successfully achieved.

The design step of wheelchair on two actuator is as follows:

3.1 Selection of materials

The prototype of project was to be made of wood so we selected hard wood as material for prototype. For achieving linear motion pair of syringes were used to demonstrate actuator.

3.2 Selection of Mechanism

A 4 bar linkage mechanism with a ternary link was designed to achieve all three positions. There are three binary links of which two linkages are part of structure and one is ternary link. To achieve desired length trial and error method is used. The mechanism is so designed that there is simultaneous motion between legrest and backrest to achieve all three desired position. Calculations were also carried out to determine angle made at the end of all three positions. Also mechanism is so placed that it should not obstruct in path of actuator and other components.

Fig. 3.1. Prototype with linkage mechanism

3.3 Number of actuator Used

Most of the wheelchairs which provide all three positons use more than two actuators which results in increase in cost power consumption, controller cost etc. But in our prototype we used two actuators. We used two syringes which acts as actuators.

Fig. 3.2 Syringe used as actuator

3.4 Fabrication of prototype

The prototype of our model with two actuators was fabricated and all three positions were achieved successfully. In sitting position, the backrest makes 20° with vertical in anticlockwise direction, seat is horizontal and leg rest makes 20° with vertical in anticlockwise direction. In standing position, the leg rest and seat are collinear making 70° with horizontal in standing position and back rest is perfectly vertical. In sleeping position the leg rest remains horizontal while backrest is inclined to some angle. The fig below shows all the three positions achieved.

Fig. 3.3. (a), (b), (c) Prototype with all three positions

Chapter 4: 3D CAD Modelling

4.1 Adopted dimensions

Following dimensions as compared to Standard dimension adopted by us are as follows:-

(Note: all dimensions are in inches)

Seat rest – 22” * 19.2”

Back rest – 22” * 36”

Leg rest – 22” * 20”. [1]

4.2 Design of wheelchair on SOLIDWORKS

After completing with wooden frame prototype. The following frame was then modelled using 3D modelling software using low carbon steel or mild steel as a material for frame. Various parameters like C.G. and working of linkage with frame was tested.

4.3 Modelling of chassis in Solid works

Chassis is an important part of wheelchair since all the components and frames are to be mounted on it. Design of chassis is such that all the parameters like C.G, forces, patient weight should be in equilibrium.

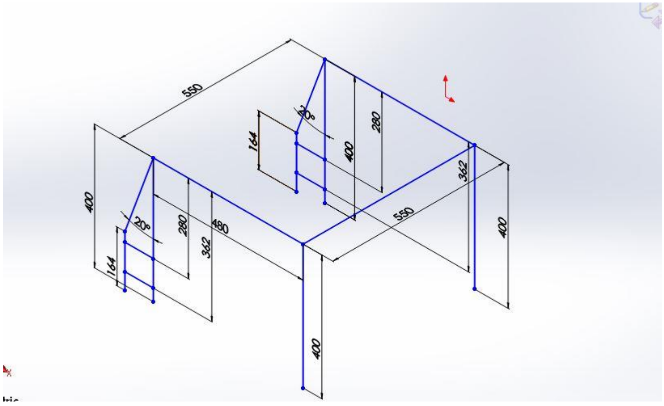


Fig. 4.1 Chassis dimension

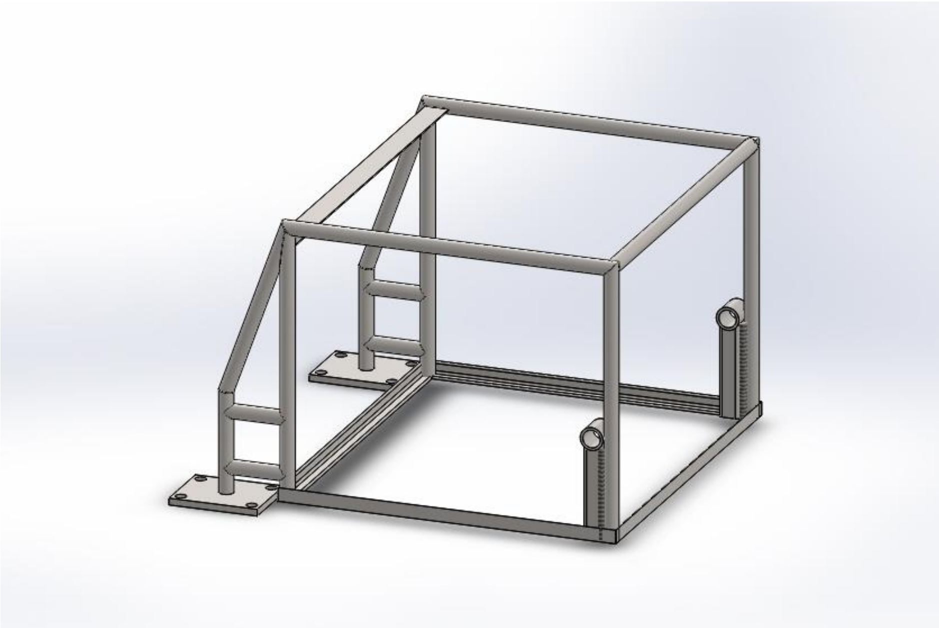


Fig. 4.2 Actual model of chassis on solid works

4.4 Determination of position of single actuator in solid works

Till now the number of actuator used to achieve three positions were two. To reduce power consumption and cost, project team started working on reducing number of actuator to one. In reducing number of actuator, various other mechanism needs to be employed with actuator. In achieving this either linkage mechanism needs to be shifted or position of actuator needs to be shifted.

So we thought of achieving three positions using single actuator by shifting position of linear actuator. The position of actuator is defined by keeping initial and extreme position of actuator and stroke of actuator as a constraint. The bottom of actuator is fixed to frame and other part of actuator needs to be fixed at two different points. We developed various mechanism as per our requirement like: -

- Hand operated lever mechanism
- Hook mechanism
- Mini linear actuators

This mechanism are discussed in chapter 7. Hence we successfully reduced number of actuator to one and achieved all positions.

4.5 Assembly of wheelchair on SOLIDWORKS

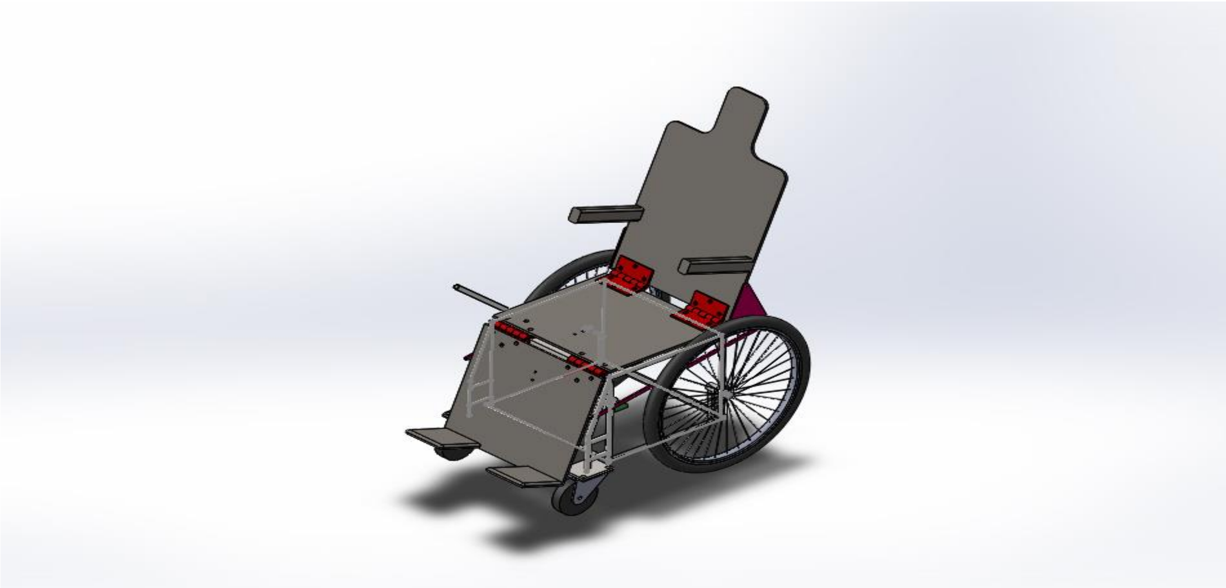


Fig. 4.3 Seating position

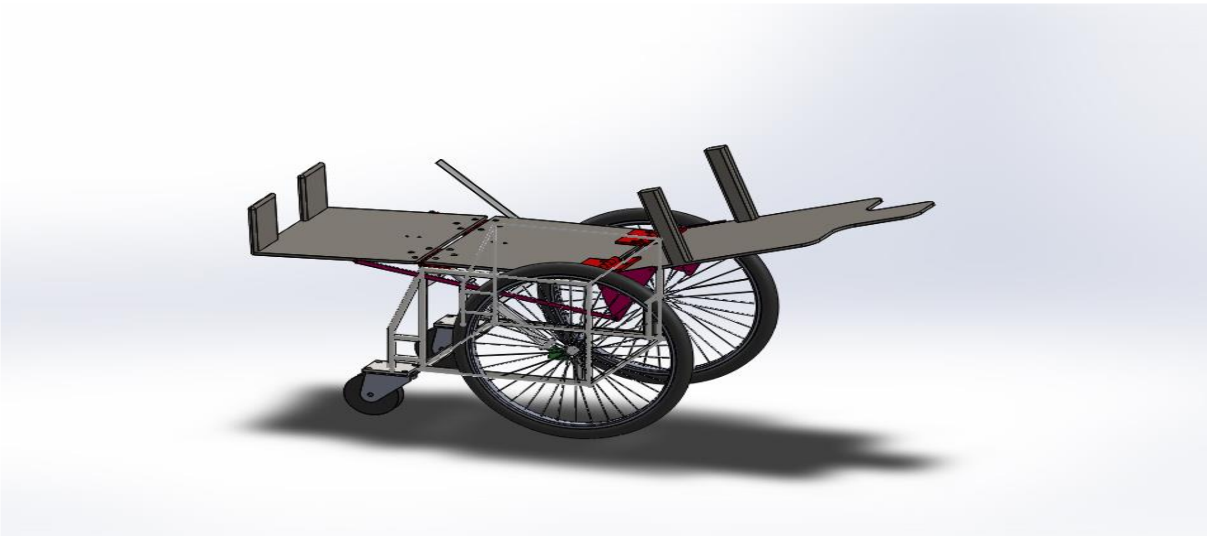


Fig. 4.4 Sleeping position

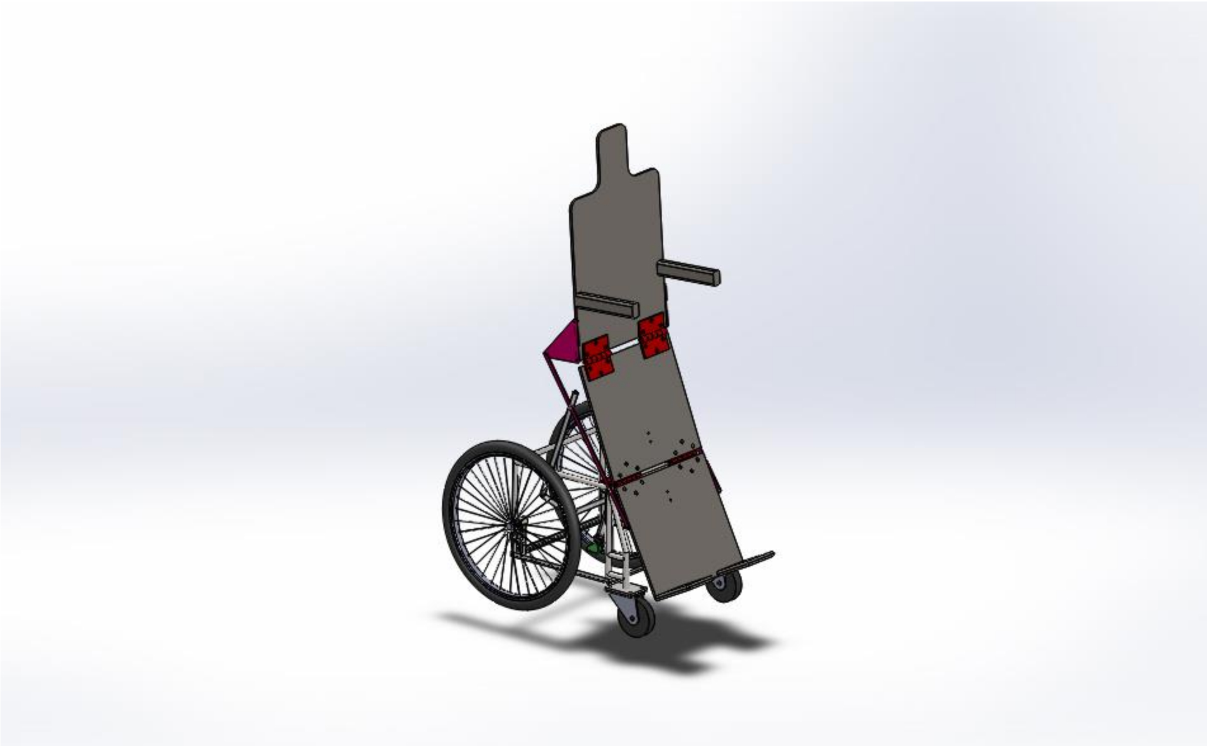


Fig. 4.5. Standing position

4.6 Determination of centre of gravity (C.G.) in solid works

To ensure the stability in all positions we need to find the C.G of the wheelchair. Determination of C.G of wheelchair on paper is very difficult but today's technology has made it simple by use of softwares. Hence the C.G determination is carried out on solid works.

From the below fig it is seen that the C.G is between rear wheel and the front wheel and also closer to the ground. Hence the structure is stable.

Fig. 4.6 Side view of wheelchair with C.G

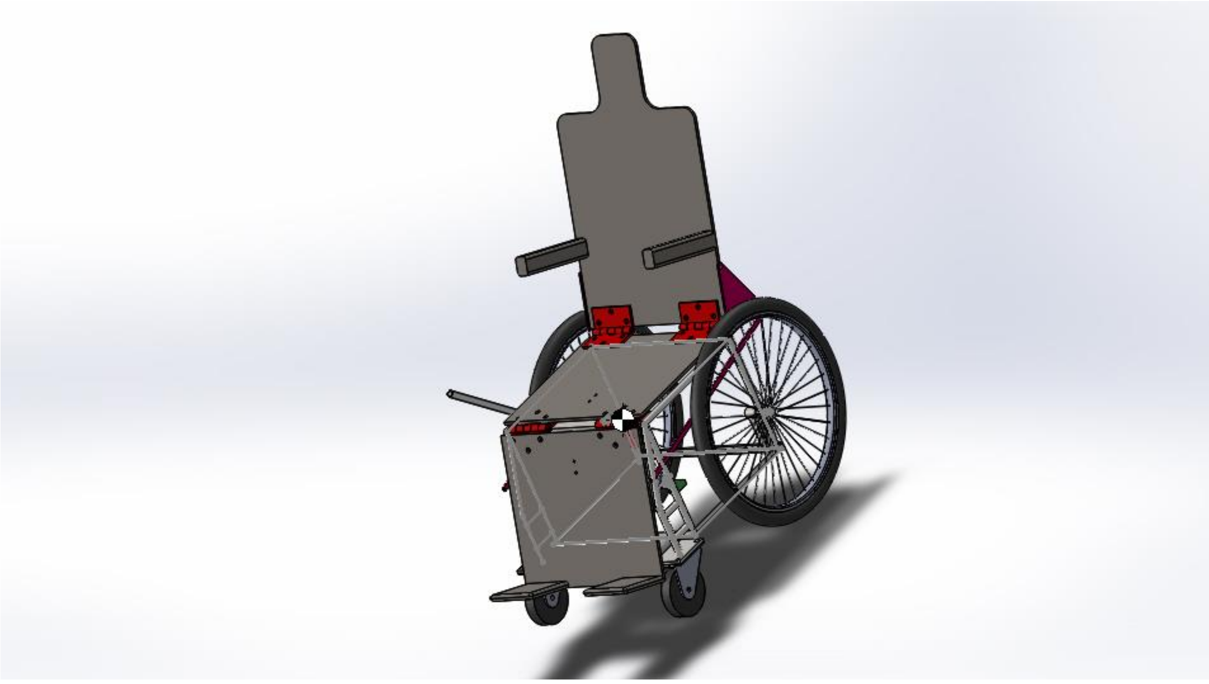


Fig. 4.7. Sitting position of wheelchair with C.G

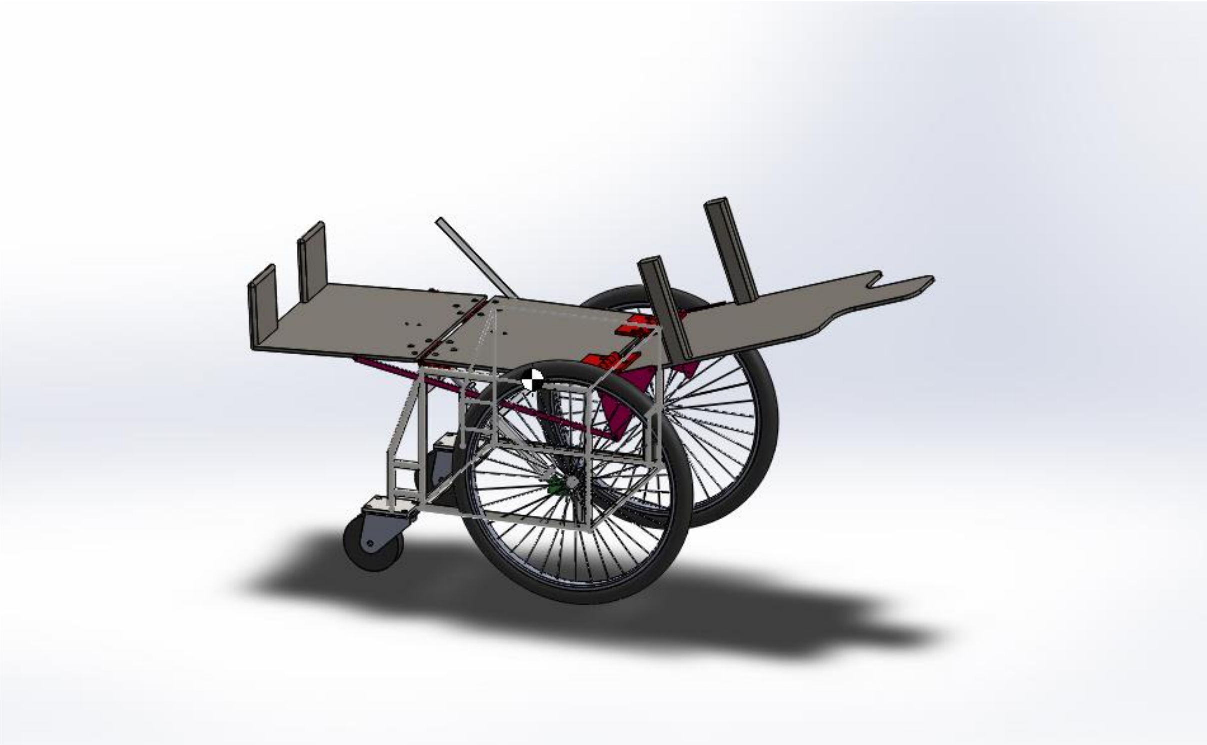


Fig. 4.8. Sleeping position with C.G

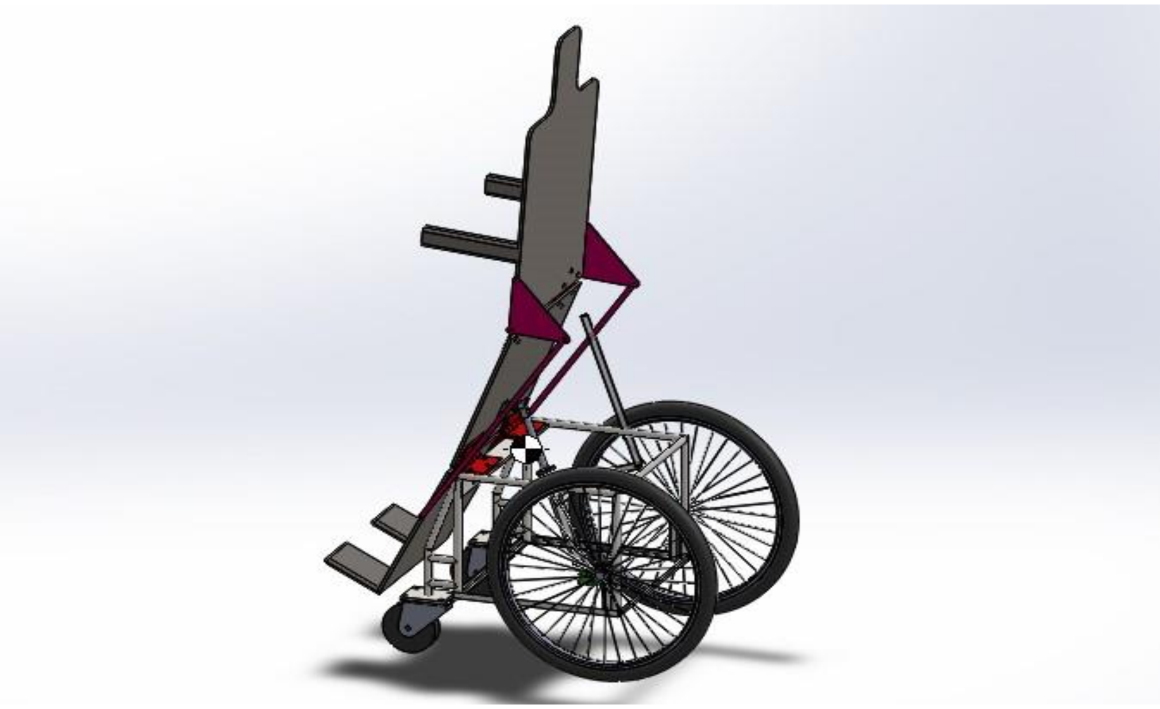


Fig. 4.9 Standing position with C.G point

Positions	X(mm)	Y(mm)	Z(mm)
Seating	**590.27**	**823.82**	**1014.17**
Sleeping	**600.53**	**828.02**	**1010.17**
Standing	**490.75**	**928.75**	**1014.17**

Table 4.1. co-ordinates of centre of gravity

From the above table ,wheelchair is symetric about Z-axis and X-axix and Y-axis varies accordingly.

Chapter 5: Structural Analysis (ANSYS)

5.1 Introduction

After finalising our design on SOLIDWORKS and paper work, we have to analyse our design, for that we have to use a software. Mathematically or on papers it is very difficult to find out different types of forces, deflection, failure, etc. on our designed wheelchair.

There are number of software available for analysis of design such like AUTODESK Inventor, ANSYS, etc. But the ANSYS was the software which was the suitable for us to use it also it gives the better results than SOLIDWORKS Inventor or any other software.

The purpose of ANSYS is that:

- To find static structural analysis.
- To find torsional analysis.
- To find various forces acting on each member and to study the failure of frame.
- To study von-Mises Stresses.
- To find the total deformation.
- To evaluate elastic strength intensity
- To find the strain energy

For completing the analysis on the specified software, we have to perform the following steps stated below as our model design is made by using a software as SOLIDWORKS.

1. Geometry clean up
2. Selection of material and applying material properties in analysis
3. Importing '.igs' file format to ANSYS
4. Definition of contacts and mesh formation
5. Defining forces and supports
6. Solution for given system using solver
7. Plotting the results

To perform the analysis on the given model in ANSYS, first of all we have to import our model into ANSYS, whereas in ANSYS, it requires '.igs' file format. But in SOLIDWORKS we have our model in 'sld.prt' format which we have to convert in '.igs' file format.

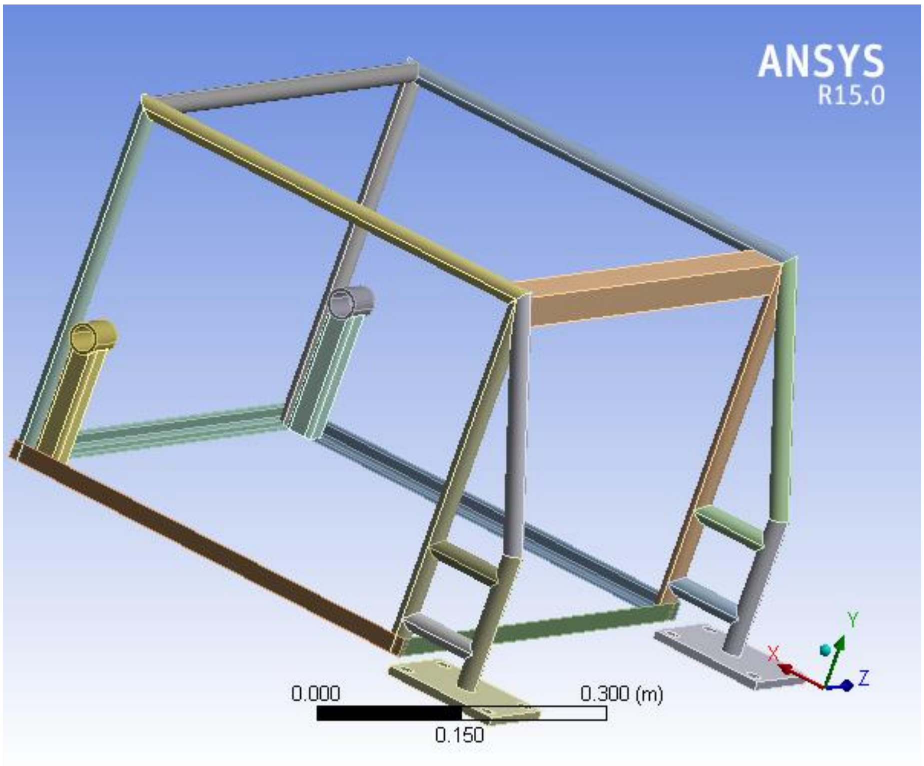


Fig. 5.1. Importing model from SOLIDWOKS to ANSYS

Object Name	Global Coordinate System
State	Fully Defined
Definition	
Type	Cartesian
Coordinate System ID	0.
Origin	
Origin X	0. m
Origin Y	0. m
Origin Z	0. m

Directional Vectors	
X Axis Data	[1. 0. 0.]
Y Axis Data	[0. 1. 0.]
Z Axis Data	[0. 0. 1.]

Table 5.1. Importing model from SOLIDWOKS to ANSYS

5.2 Geometry Clean-up

Geometry clean-up is a task to clarify all the connections and joints of the model given. If we do not go for geometry clean-up, the software used ANSYS will not accept the model made as it will not be able to mesh it.

When we were importing our SOLIDWORKS .igs file to our analysis software ANSYS and were trying to mesh it, it was not accepted by ANSYS. Because of improper geometry connections software was unable to mesh our model, this was due to undefined contact types. For that we clean up the geometry and defined the every joint so that ANSYS can read it. But the geometry cleaning process we did in SOLIDWORKS.

First of all found that contacts which the ANSYS cannot read by using a command in ANSYS as ‘contact tools’. There were two types of bad-contacts as intersections and large gaps. These corrections were corrected in SOLIDWORKS. The intersections were removed by the tool extrude command. And the large gaps were also filled by using weldment feature of SOLIDWORKS and file was again imported to ANSYS.

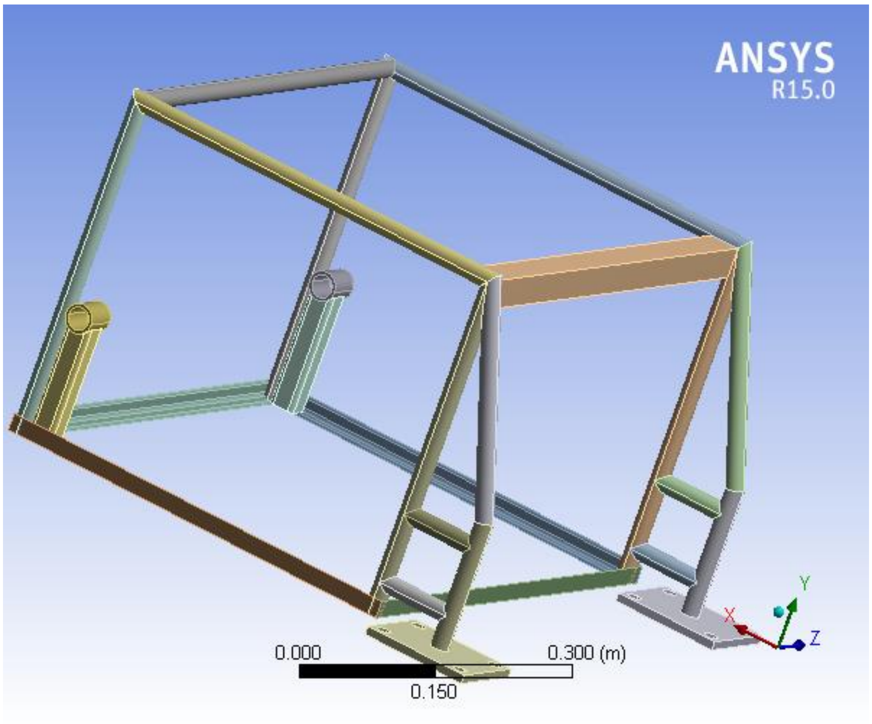


Fig. 5.2. Geometry clean up

Object Name	Geometry
State	Fully Defined
Definition	
Source	C:\Users\SBT\Desktop\frtest.IGS
Type	Iges
Length Unit	Meters
Element Control	Program Controlled
Display Style	Body Color
Bounding Box	

Length X	0.64714 m
Length Y	0.42065 m
Length Z	0.654 m

Table 5.2. Geometry clean up

5.3 Material Selection

We selected MS 1018 material for analysis of our structure. And on the basis of obtained by different resources' results, we selected the AISI 1018 as our vehicle material.

We gone to the material library of our software i.e ANSYS but in that library we did not find our chosen material, therefore we made a new material there as MS 1018 on the basis of our predefined material's standard properties.

When we assigned our made material to the model we found the different values of properties of our vehicle as given in the following table:

Temperature C	Young's Modulus Mpa	Density	Poisson's Ratio	Bulk Modulus Mpa	Shear Modulus Gpa
22	205	7870 kg m^-3	0.29	162.7	79.45

Table 5.3. Material Properties

5.4 Import of Geometry

As explained in section 5.1 we have to import the SOLIDWORKS ‘sld.prt’ file into ‘.IGS’ file format and the IGS file is generated to ANSYS.

5.5 Connections and Mesh

5.5.1 Different Contacts

As we imported the geometry, ANSYS has automatically identified the free geometry, single geometry and multiple geometry and we also identified the different types of connections.

Object Name	Geometry
State	Fully Defined
Definition	
Source	C:\Users\SBT\Desktop\frtest.IGS
Type	Iges
Length Unit	Meters
Element Control	Program Controlled
Display Style	Body Color
Bounding Box	
Length X	0.64714 m
Length Y	0.42065 m
Length Z	0.654 m

Table 5.4. Contacts

5.5.2 Mesh

Meshing is probably the most important part in any of the computer simulations, because it can show drastic changes in results we get. Meshing means creating a closed geometry of some grid-points called ‘nodes’. The results are calculated by solving the relevant governing equations numerically at each of the nodes of the mesh. The governing equations are almost always a partial differential equations and finite element method (FEA) is used to find solutions to such equations. The pattern and positioning of nodes also affects the solution, good meshing is very essential for a computer simulation to give better results.

In our model we also did the meshing after importing and identifying the connections in ANSYS software. There three types of meshing are available with this software as fine meshing, medium meshing and coarse meshing. We did the coarse meshing as we were doing a student level project and also as the fine meshing takes more time to give us the results.

The geometry of mesh can be of any shape as triangular meshing or quadrilateral meshing, etc. but here we did the triangular meshing as it was program controlled and we did not changed it. We can see that in table it is shown as program controlled.

Object Name	Geometry
State	Fully Defined
Definition	
Source	C:\Users\SBT\Desktop\frtest.IGS
Type	Iges
Length Unit	Meters
Element Control	Program Controlled
Display Style	Body Color
Bounding Box	

Length X	0.64714 m
Length Y	0.42065 m
Length Z	0.654 m

Table 5.5.1. Meshing (1)

Inflation	
se Automatic Inflation	None
Inflation Option	Smooth Transition
Transition Ratio	0.272
Maximum Layers	5
Growth Rate	1.2
Inflation Algorithm	Pre
View Advanced Options	No
Patch Conforming Options	
Triangle Surface Mesher	Program Controlled
Nodes	36396
Elements	9496

Table 5.5.2. Meshing (2)

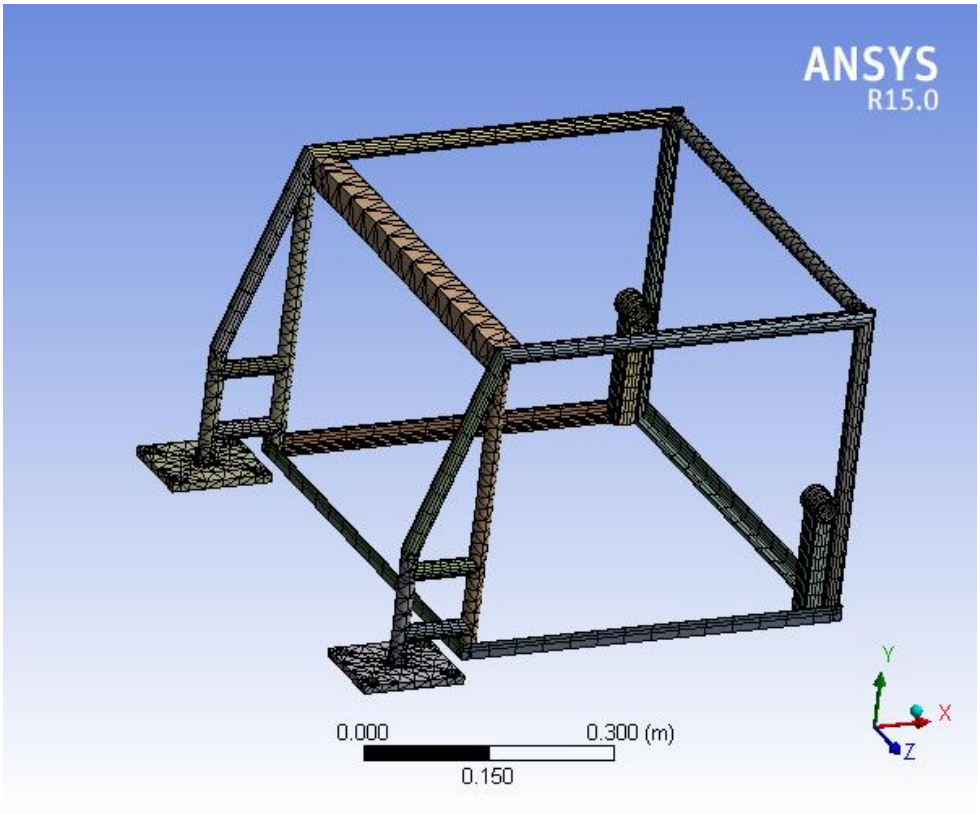


Fig. 5.3: Mesh Analysis

5.6 Supports and Forces

5.6.1 Supports

To find out the magnitude of the forces, such like in mathematical problems we have to fixed the different types of supports such as fixed support, hinged support, roller support or pin support, etc. we have to define it. Supports are thought of in terms of degree of freedom (DOF) available for the elements used. Supports, regardless of actual names, are always defined in terms of degree of freedom. Supports having a direction components can be defined in global or local coordinate system.

In our model we have fixed four part of the chassis which namely two plate which support the castor wheel at the front of chassis and two bearing hub at the rear of chassis. since load is transferred from supporting plate to castor wheel at the front while bearing hub transferred load from hub to bearing, bearing transferred load to driving wheel shaft and finally to ground through driving wheel.

Below table shows condition of support on chassis.

Object Name	Fixed Support	Force
State	Fully Defined	
Scope		
Scoping Method	Geometry Selection	
Geometry	4 Faces	1 Face
Definition		
Type	Fixed Support	Force
Suppressed	No	
Define By		Vector
Magnitude		-1079. N (ramped)
Direction		Defined

Table 5.6. Fixed supports

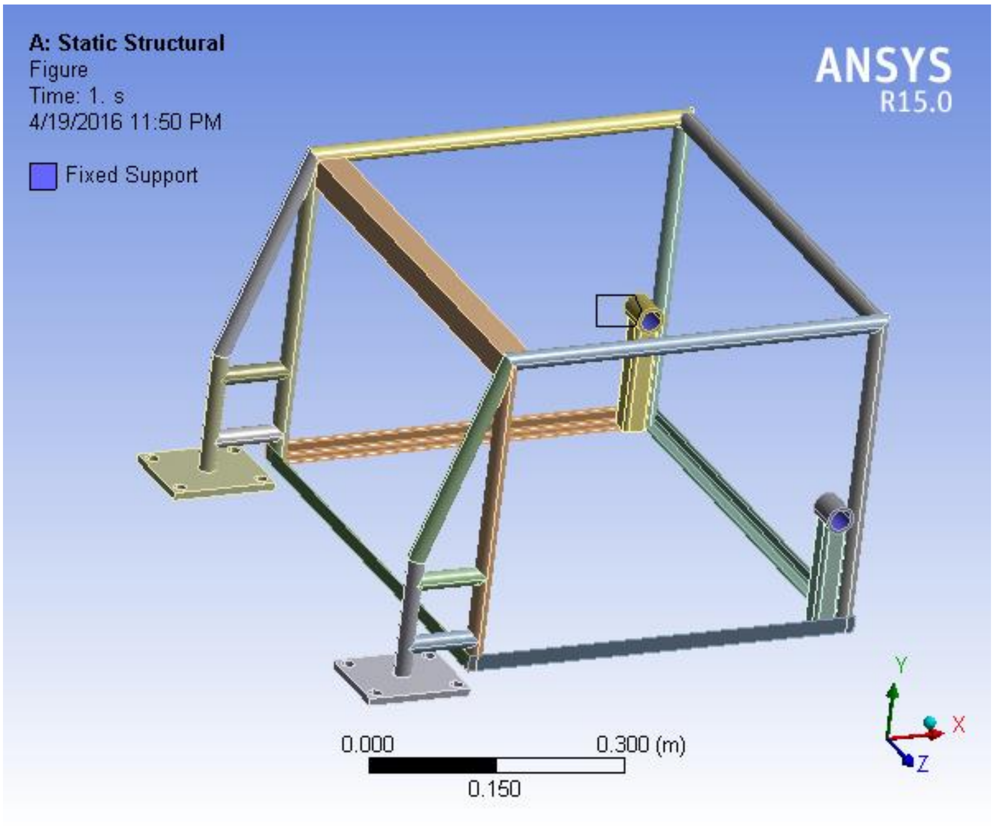


Fig 5.4. Fixed Supports

5.6.2 Forces (Loads)

These are the actual reasons for the failure of any system. There are different types of loads acting on the entire system which are as follows:

1. Inertial loads:
   These loads act on the entire system where density is required for mass calculations and these are only loads which act on defined point masses.

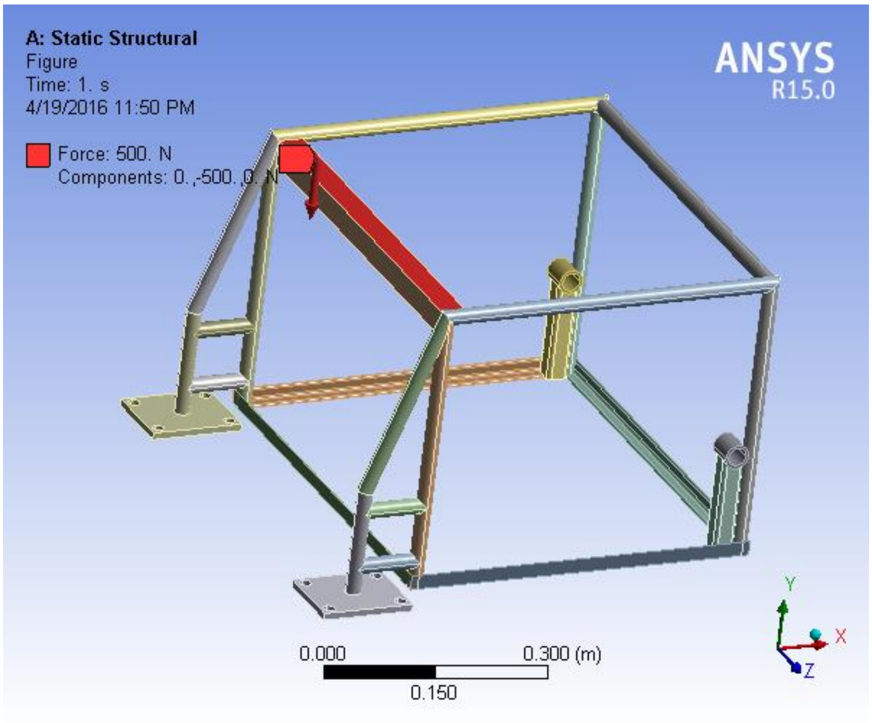
2. Structural loads:
   Forces or moments acting on parts of system.

3. Structural supports:
   Constraints that prevent movements on certain regions.

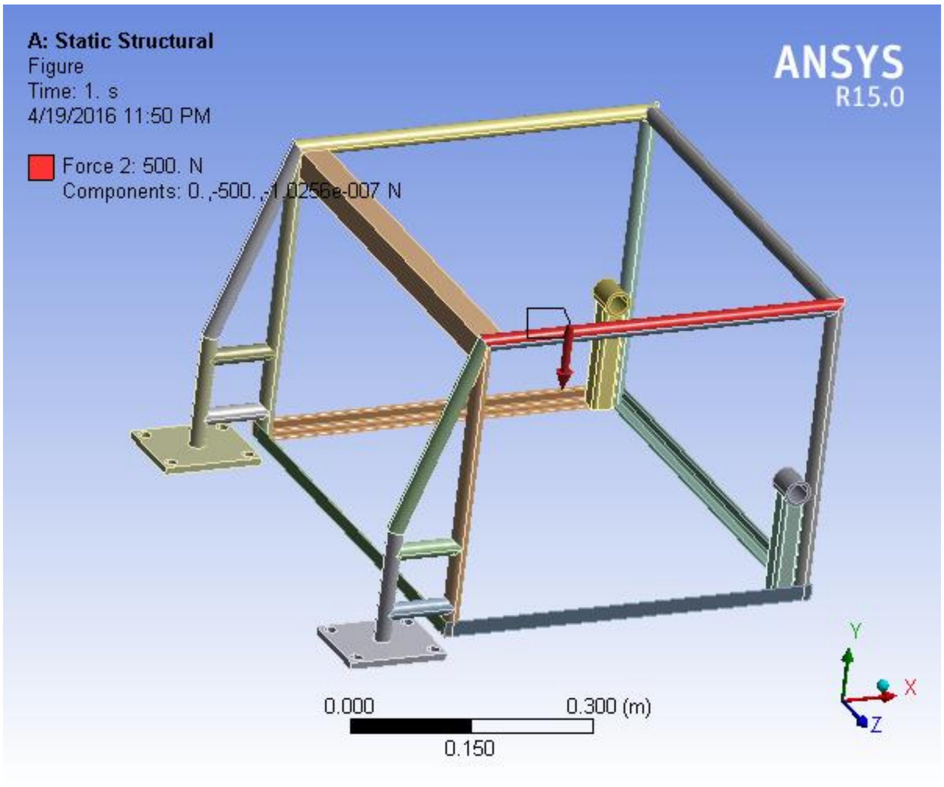
Total Load Magnitude=200kg=200*10=2000N

Object Name	Fixed Support	Force
State	Fully Defined	
Magnitude	2000N	

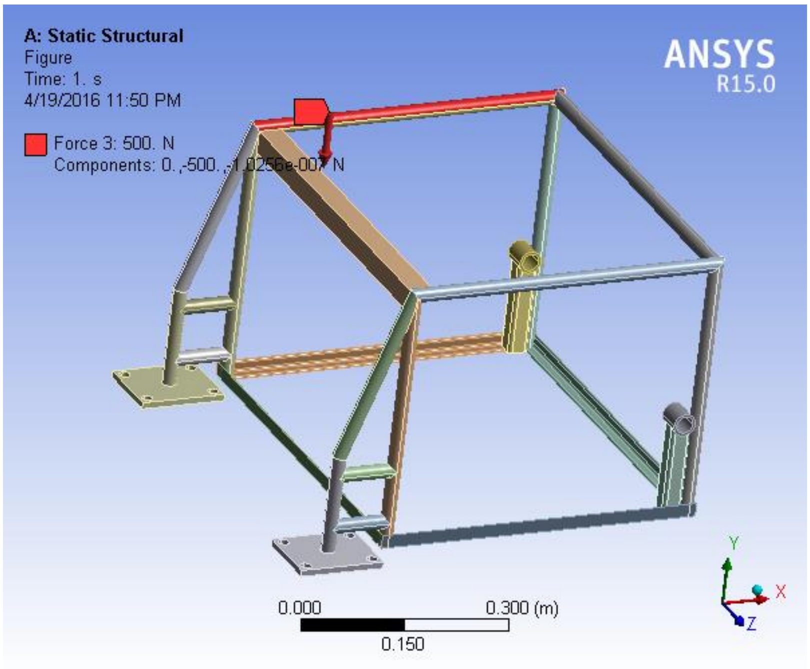
Table5.7. Force



(a)


A: Static Structural
Figure
Time: 1. s
4/19/2016 11:50 PM
Force 2: 500. N
Components: 0. ,-500. ,-1.0256e-007 N
ANSYS
R15.0
0.000
0.300 (m)
0.150
Y
X
Z

(b)


A: Static Structural
Figure
Time: 1. s
4/19/2016 11:50 PM
Force 3: 500. N
Components: 0. ,-500. ,-1.0256e-007 N
ANSYS
R15.0
0.000
0.300 (m)
0.150
Y
X
Z

(c)

Fig. 5.5. Forces

5.7 Solution information

For solution we have selected results of analysis to display the different stresses, deformations, graphs (linear or non-linear) etc. But we have focused on these:

1. Von-Mises Stresses
2. Total deformation
3. Elastic strength intensity.
4. Strain energy

These are shown in figures given below (Fig.):

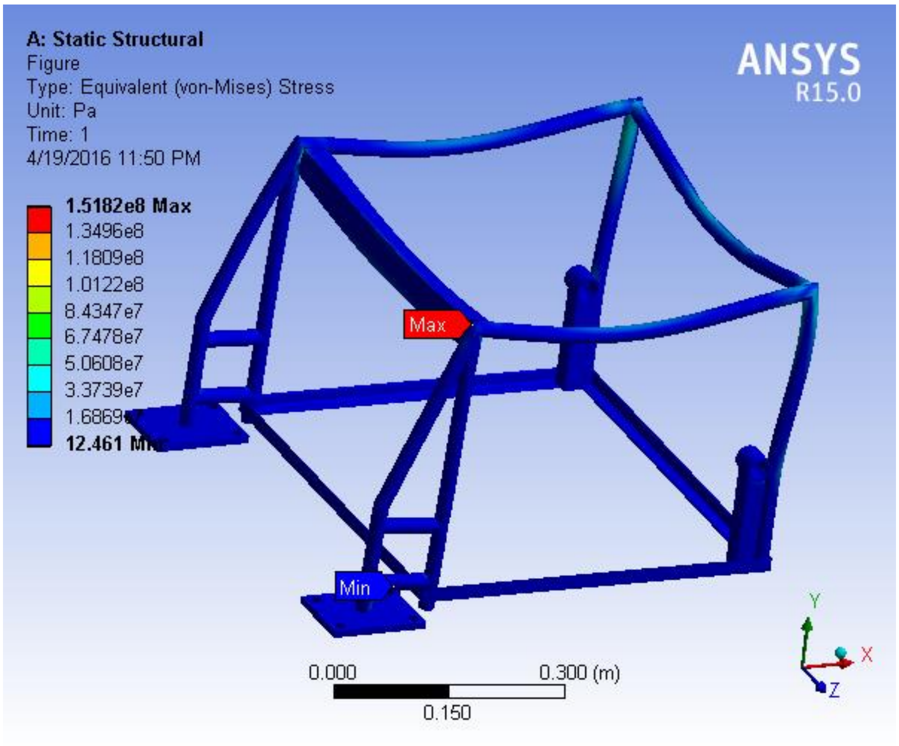


Fig. 5.6.1. Von-Mises Stresses

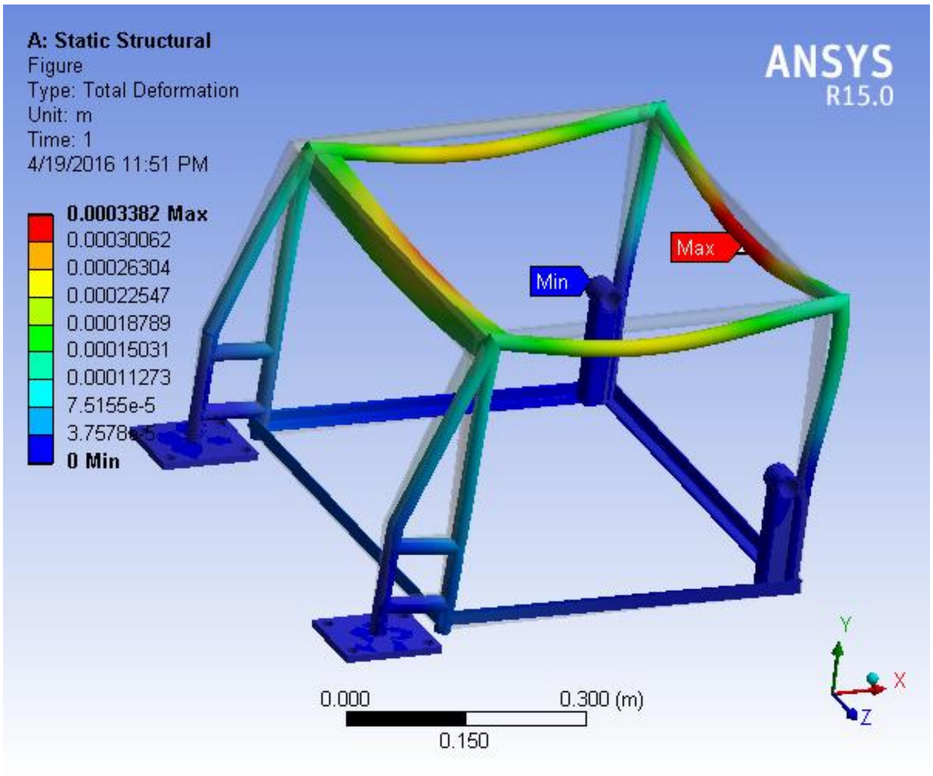


Fig. 5.6.2. Total Deformation

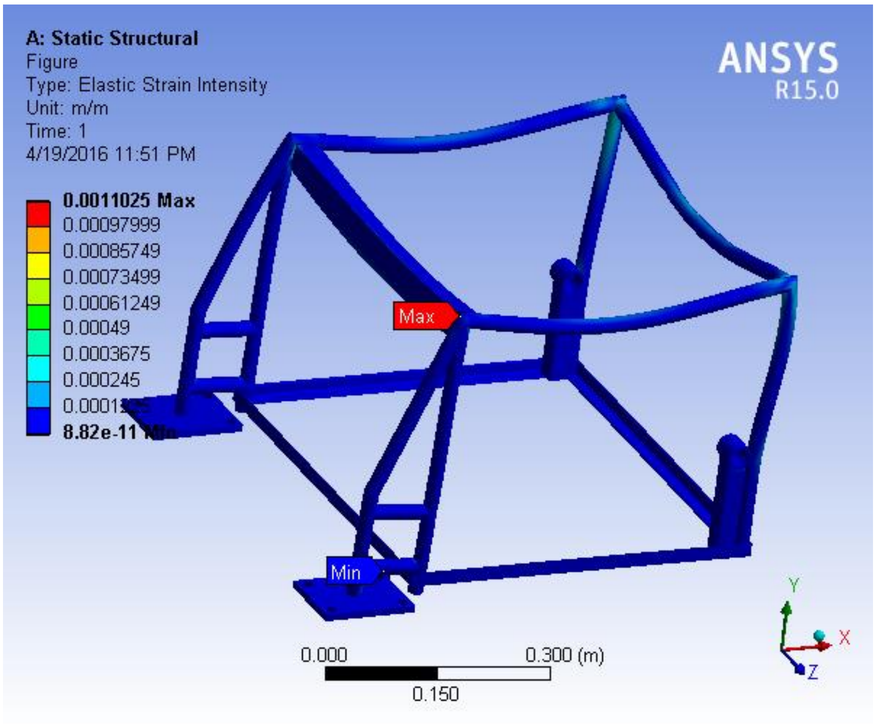


Fig. 5.6.3. Elastic Strain Intensity

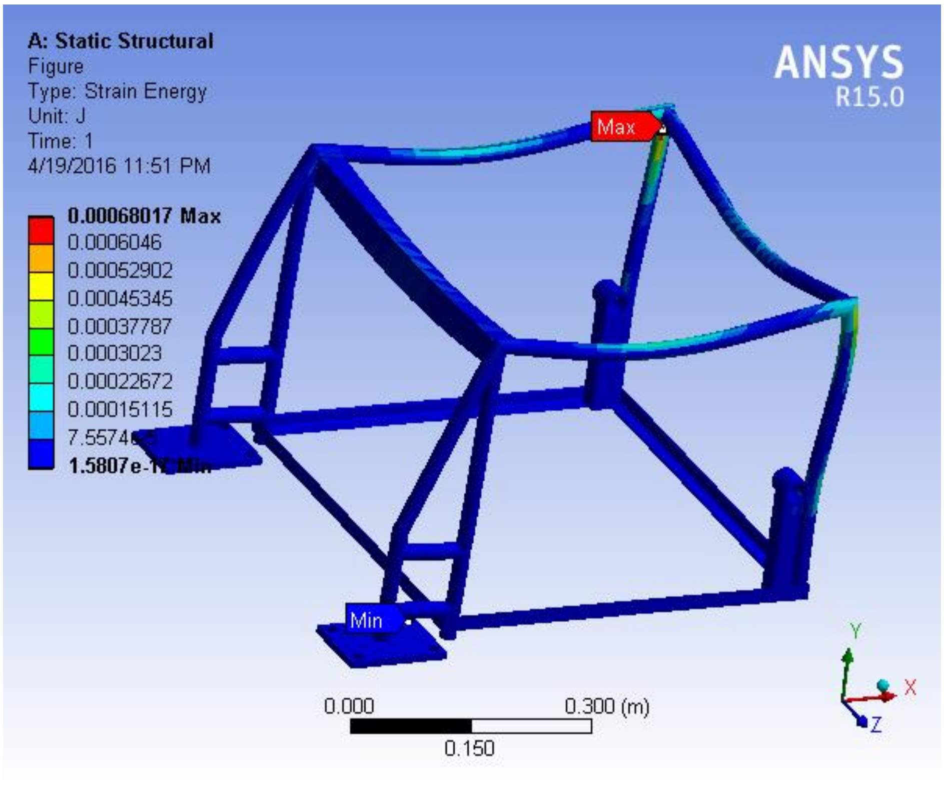


Fig. 5.6.4. : Strain Energy

5.8 Solution

By applying all the relative values and prerequisite to the solver of the software ANSYS we get all the values of stresses, total deformation, elastic strain intensity and strain energy that is the minimum and the maximum values of all these factor we got in tabular form such as given as follows:

Object Name	Equivalent Stress	Total Deformation	Elastic Strain Intensity	Strain Energy
State	Solved			
Scope				
Scoping Method	Geometry Selection			

Geometry	All Bodies			
Definition				
Type	Equivalent (von-Mises) Stress	Total Deformation	Elastic Strain Intensity	Strain Energy
By	Time			
Display Time	Last			
Calculate Time History	Yes			
Identifier				
Suppressed	No			
Integration Point Results				
Display Option	Averaged		Averaged	
Average Across Bodies	No		No	
Results				
Minimum	12.461 Pa	0. m	8.82e-011 m/m	1.5807e-017 J
Maximum	1.5182e+008 Pa	3.382e-004 m	1.1025e-003 m/m	6.8017e-004 J
Minimum Occurs On	Part 23	Part 14	Part 23	
Maximum Occurs On	Part 4	Part 9	Part 4	Part 5

Minimum Value Over Time				
Minimum	12.461 Pa	0. m	8.82e-011 m/m	1.5807e-017 J
Maximum	12.461 Pa	0. m	8.82e-011 m/m	1.5807e-017 J
Maximum Value Over Time				
Minimum	1.5182e+008 Pa	3.382e-004 m	1.1025e-003 m/m	6.8017e-004 J
Maximum	1.5182e+008 Pa	3.382e-004 m	1.1025e-003 m/m	6.8017e-004 J
Information				
Time	1. s			
Load Step	1			
Sub step	1			
Iteration Number	1			

Table 5.8. Results obtained

5.9 Conclusion

By Table we know that the ultimate stress value as 440 MPa and from fig. we can see that the max stress value obtain is 151.8 MPa, hence it is found as a safe selection of material and safe loading.

Chapter 6: Fabrication of base and frame

6.1 Material selection

The chassis is made up of MS 1018. This material was selected due to its good combination of all of the typical traits of steel strength, ductility, and comparative ease of machining and weldability.

The properties of material are presented in the table.

PROPERTIES	VALUE
Modulus of elasticity (MPa)	205
Hardness, Brinell	126
Tensile strength, Ultimate	440 MPa
Density	7870 kg/m3
Bulk modulus	162 MPa
Poisons Ratio	0.290
Shear Modulus	79.45 GPa

Table 6.1. Material properties

6.2 Pipe cutting

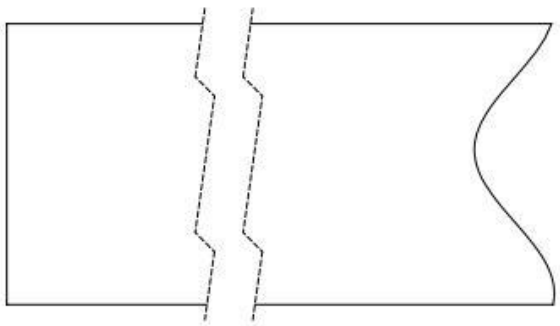
After selecting the materils as MS 1018 for chasiss and frame we cut the pipe according to the dimensions.

Fig. 6.1. Pipe cutting on cutter machine

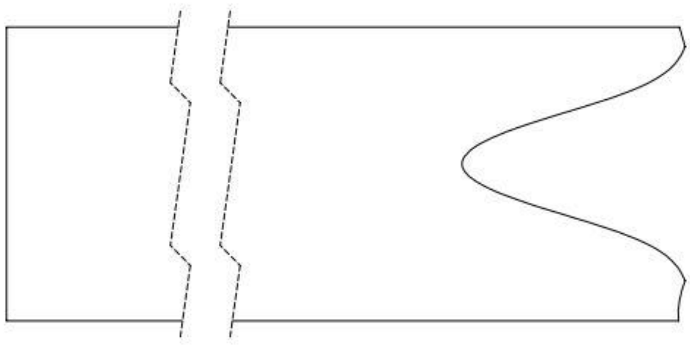
6.3 Profile cutting

As we know that for welding two pipe it is easy to weld by overlapping each other but in our chassis there are so many of corners which comprising of three pipe at a single corner.so it is difficult to weld three pipe to make a perfect corner. To make the perfect corner we had to go through the process of profile cutting on each pipe and welding it.

The process of profile cutting is done by using the software SOLIDWORKS.



(a)



(b)

Fig. 6.2. Profile cutting on SOLIWORKS

Fig. 6.3. Actual fabrication of pipe profiles

Fig. 6.4. Profile cutting process

6.4 Welding machine and electrode specification

Welding electrode used:

Mild steel electrode:

Electrode for general purpose welding

(AWS 6013, IS 814/ER4211X)

Electrode of this group are medium coated rutile type with coating factor below 1.3. [6]

Application:

They are suitable for all position welding of structures not subjected to dynamic loading. [6]

Ultimate Tensile Strength (U.T.S.)	47 kgf /mm^2 (min.)
Yield Strength (Y.S)	39 kgf /mm^2 (min.)
Percent Elongation	17% (min.)

Table 6.2. Mechanical Properties [6]

Sizes:

Gauge	Sizes
4	6.3 mm x 450 mm
6	5.0 mm x 450 mm
8	4.0 mm x 450 mm
10	3.15 mm x 450 mm
12	2.5 mm x 350 mm

Table 6.3. Welding electrode size with gauge.

6.5 Electrode Used:

Orange E6013 Gauge 10

Range of Electrode Current

Sr. No.	Electrode Diameter (mm)	Gauge	Current (Ampere)
1	2.00	14	50 to 70
2	2.5	12	70 to 100
3	3.15	10	90 to 120
4	4.00	8	140 to 180
5	5.00	6	200 to 250
6	6.30	4	270 to 320

Table 6.4. Rating of Electrodes

Note: Current Setting depends on welding position and skill of welder. For Stainless Steel Welding 30% less current to be used. For good quality and better finished weld bead. [6]

6.6 Welding of chassis

The base was fabricated wholly with M.S. material so that welding process can be simplified. Standard materials were used for fabrication work.

½ inch round pipe with 2mm thickness were used for base frame of wheelchair. 25mm x 3mm angle is used for base where battery and additional accessories has to be kept, 35mm x 5mm angle is used in main frame between seat and leg rest to take excess load and transfer to base. For bolting caster wheel a plate of dimension 150mm x 100mm with thickness of 5mm is used.

For fabrication work general arc welding is used electrode with 3.15mm having gauge 10 is used. Current used for welding is 90 -120 Ampere. AWS E6013 is used.

Fig. 6.5. Chassis fabrication

6.7 Square frame

Square frame was designed for back rest, seat and leg rest. The size of pipe being ¾ inch x ¾ inch. Since welding is to be made at right angle hence 45° cutting is to be made.

(a) (b) (c)

Fig. 6.6. Seatrest, Legrest, Backrest

Chapter 7: Mechanism and component used

7.1 Mechanism used for shifting the actuator

7.1.1 Hand operated lever mechanism

There are many wheelchairs that gives three positions like our wheelchair but they used more than three actuators which makes them costly as well as power consumption is very high. So we had used single actuator in our wheelchair. But there was problem to achieve three positions with single actuator.

For this we had make use of hand operated lever mechanism which patient can used to move the actuator from leg rest to seat rest to achieve the sleeping or standing position as per requirement of patient.

The lever mechanism has to travel a angle of 36.5 ^{0} for obtaining its desired position and for this we had made guide of same angle so that lever can smoothly follow the path.

The fig below shows the guide and lever mechanism.

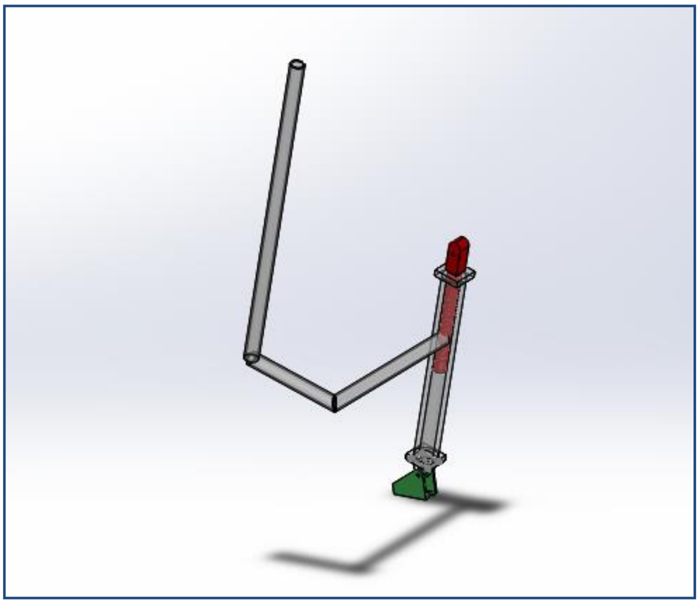


Fig.7.1. Lever mechanism

7.1.2 Hook mechanism

After assembling of square frame with linkage system there was one problem which we were facing. The problem was not so big but was very important to solve.

There is simultaneous motion between leg rest frame and backrest frame which is necessary for both positions i.e standing as well as sleeping position.when person wants to shift from seating position to standing position he has to shift the actuator from leg rest to seat rest position and this shifting process will take some time and there is a chance that leg rest will move up and due to this person is directly going to sleeping position instead of standing. To avoid this we had arisen to a solution that we will use hook mechanism as a locking system.

Hook is fitted on the main chassis pipe and there is a pipe welded on the leg rest. When person wants to shift between seating and standing position the hook should be engaged and when the person wants shift between seating and sleeping position then first he has to shift the actuator and engage it near leg rest and then he has to unlock the hook so that the actuator can convert seating position to sleeping position. The fig.shown below is the hook which we had used in our wheelchair.

Fig.7.2. Hook mechanism

7.1.3 Collinear electromechanical actuator mechanism:

In order to achieve both the position i.e. sleeping and standing by using a single electric linear actuator we first decided to use brake which is used in bicycle but after certain trial and error we did not achieved required result. So we switch to another mechanism i.e use collinear electromechanical actuator. This actuator consist of 4 main components DC geared motor 12V, Bolt and Nut, Sleeve and Pin. It converts rotary motion of motor shaft to reciprocating motion of pin. This helps engagement and disengagement of pin from actuator and actuator becomes free to move from its initial position.

Fig. 7.3. Components of collinear actuators

Fig. 7.4. Assembly of collinear actuators

7.2 Component

7.2.1 Driving wheel

The basic chair has two 24-inch diameter rear wheels and two 6-inch diameter caster wheels in the front. Overall length without the front rigging varies between 30 5/8 and 32 inches, depending upon model and manufacturer. The standard rear wheel for many years has been a wire spoke wheel, but wheels of cast metal alloy and wheels of cast plastic have been made available recently to overcome the maintenance problems inherent in the wire wheel design, yet not weigh any more.

There are three types of wheelchair tires, air filled, solid and foam filled or flat free inserts. The tires will be a factor on how easily the wheelchair will roll over all terrain. Generally the harder the tire, the easier the wheelchair will roll and turn corners. The softer the tire, the harder it will be to propel the wheelchair.

Air tires are fairly common on the rear of a wheelchair because they will roll over soft terrain easier and give a better ride than solid tires. The disadvantage of air tires is they will go flat if punctured and they will go soft even without any damage eventually. An air tire that is under inflated makes the wheelchair hard to push and causes excessive wear on the tires. Air tires and tubes need to be replaced more often than solid tires.

Solid tires are the best tires for those who want a wheelchair to roll as possible but they give the roughest ride over bumps and ridges in the ground surface. The biggest advantage is they are virtually maintenance free, they won't go flat and they won't likely wear out in the life of the wheelchair. Solid tires are most suitable for wheelchairs that are expected to stay indoors most of the time such as nursing home use.

Tires which we had used is air tires as it is cheap, comfortable, and has shock absorbing features.

Fig. 7.5. Driving wheel

7.2.2 Castor wheel

A **caster** (or **castor**) is an undriven , single, double, or compound wheel that is designed to be mounted to the bottom of a larger object (the "vehicle") so as to enable that object to be easily moved. They are available in various sizes, and are commonly made of rubber, plastic, nylon, aluminum, or stainless steel. [1]

Casters are found in numerous applications, including shopping carts, office chairs, and material handling equipment. High capacity, heavy duty casters are used in many industrial applications, such as platform trucks, carts, assemblies, and tow lines in plants. Generally, casters operate well on smooth and flat surfaces. [1]

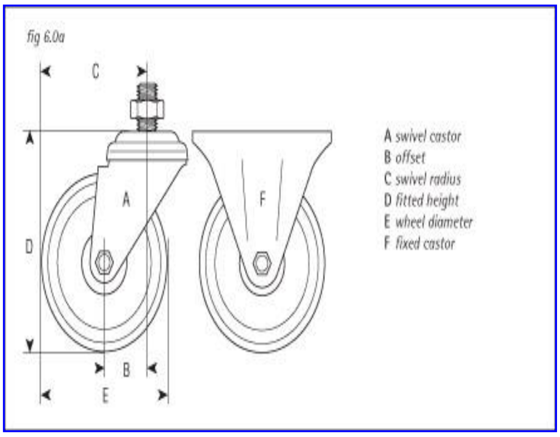


Fig. 7.6. Dimension of caster wheel

Fig. 7.7. Caster Wheel

● Rubber caster with steel core, roller bearing

75×20		50	94	28	70×59	53×40	8.5	4001-75
85×25		60	105	32	102×84	72×60	9×14	4001-85
100×30		70	121.5	32	102×84	72×60	9×14	4001-100
125×37		100	147	35	102×84	72×60	9×14	4001-125
150×40		130	190	50	131×104	105×77	11×16	4001-150
160×40		145	192	52	131×104	105×77	11×16	4001-160
200×50		185	233	52	131×104	105×77	11×16	4001-200
250×50		210	282	52	131×104	105×77	11×16	4001-250

Table 7.1. Selection of Caster Wheel

7.2.3 Actuator

Linear Actuator is being selected to achieve linear motion.

Types of Linear Actuator

There are various types of actuator available i.e. mechanical, pneumatic, hydraulic and electric linear actuator.

Since hydraulic actuator needs additional pump, heavy in construction. So hydraulic actuator is not desired.

Pneumatic actuator creates a sudden push or pull which can be dangerous for wheelchair user. Hence Pneumatic actuator cannot be used.

Mechanical actuator is heavy in construction. Weight per stroke length is more compared to electric linear actuator.

Linear actuator will be better option than the other three actuator.

Load calculation

Assuming maximum load that an actuator can take is 100 kg.

Assuming load factor to be 1.5 (including weight of frame and load safety factor)

Designed load = 100 x 1.5 = 150 kg (1500N)

Speed of actuator

The angle turned by actuator from sitting to standing and from sitting to sleeping is same which is 70°. The length of actuator required is 200mm

Let the time taken to turn 70° be 50 sec. This means for 200mm of actuation it will take 50 sec.

So, the maximum actuator speed required is 200/50 = 4mm/sec.

Static load Capacity

Linear screw actuator can have a static loading capacity, meaning that when motor stops the actuator essentially locks in place and can support a load that is either pulling or pushing on the actuator. The static loading capacity increases mobility and speed.

The acme threads have high static load capacity, while screw threads have low load capacity and can be nearly free floating.

Since maximum load on actuator is 150kg. Minimum 150kg of static load capacity of actuator is needed.

Dynamic load capacity

Dynamic load capacity is typically referred to as the amount linear actuator is capable of providing during operation.

Desired dynamic capacity should be above 150kg.

Duty cycle

Duty cycle refer to amount of time actuator can run before ot needs to cool down.

As the duty cycle exceeds, loss of power, overheating and eventually burning of motor is risked. Generally actuator has a duty cycle of 10 to 25%

Selecting on lower side so as to have good life and reliability of actuator.

Desired duty cycle be 10% - 15%

Figure below shows 10% duty cycle of an actuator. T_{ON} is the time for which actuator is in ON state and T_{OFF} is the time for which the actuator is in OFF state. This graph should be followed for better and efficient working of actuator by letting it cool in OFF state.

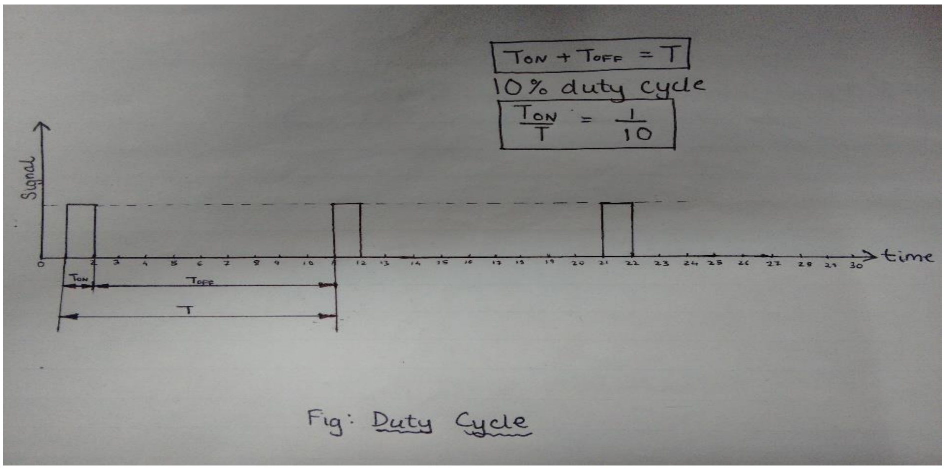


Fig. 7.8. Duty Cycle of 10%.

Parameters	Specification
Voltage	12V DC
Current	3A max.
Dynamic Load Push	6000N
Dynamic Load Pull	4000N
Static Load Push	6000N
Static Load Pull	4000N
Speed at full load	3mm/s
Mounting position	H type, V type and 45°
0Limit Switch	Built in
Overload Protection	Integrated in appropriate control box
Duty cycle	10% max
IP Grade	IP43
Operating Temperature	+5°C to +40°C
Standard	CE/UL

Table 7.2. Specification of our Actuator (JEICANG JC35D)

Fig. 7.9. Jiecang JC35D Electric Linear Actuator

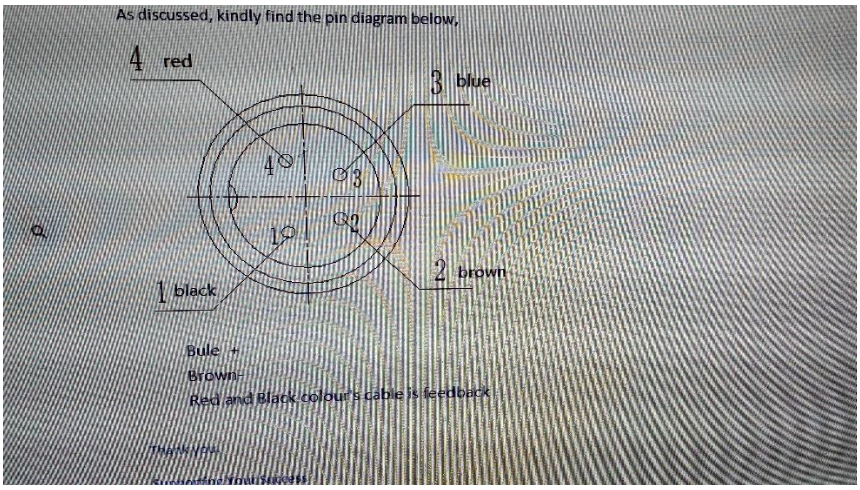
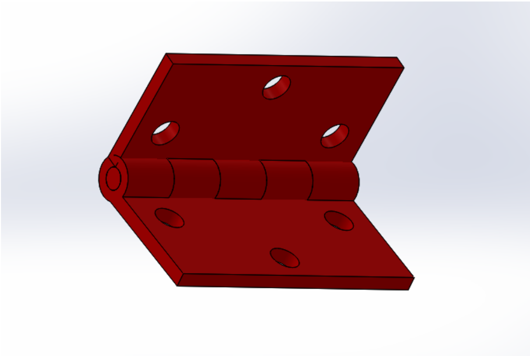


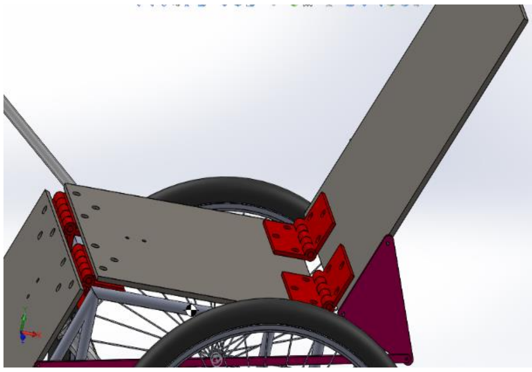
Fig.7.10. Pin diagram of actuator connector

7.2.4 Hinges

A **hinge** is a mechanical bearing that connects two solid objects, typically allowing only a limited angle of rotation between them. Two objects connected by an ideal hinge rotate relative to each other about a fixed axis of rotation. Hinges may be made of flexible material or of moving components.



(a)



(b)

Fig.7.11. Hinges attached on the frame

Testing of Hinges on UTM

A test of hinges on UTM (Universal Testing Machine) was carried to find Ultimate Tensile Strength of Hinges. Since hinges was to be used in our structure where load was quite high, therefore it was desirable for us to have high tensile strength of hinges.

In testing the Ultimate Tensile Strength (σ_{ut}) of hinge comes to be 1.80 KN/Kg.

Fig. 7.12 Digital indicator showing applied force

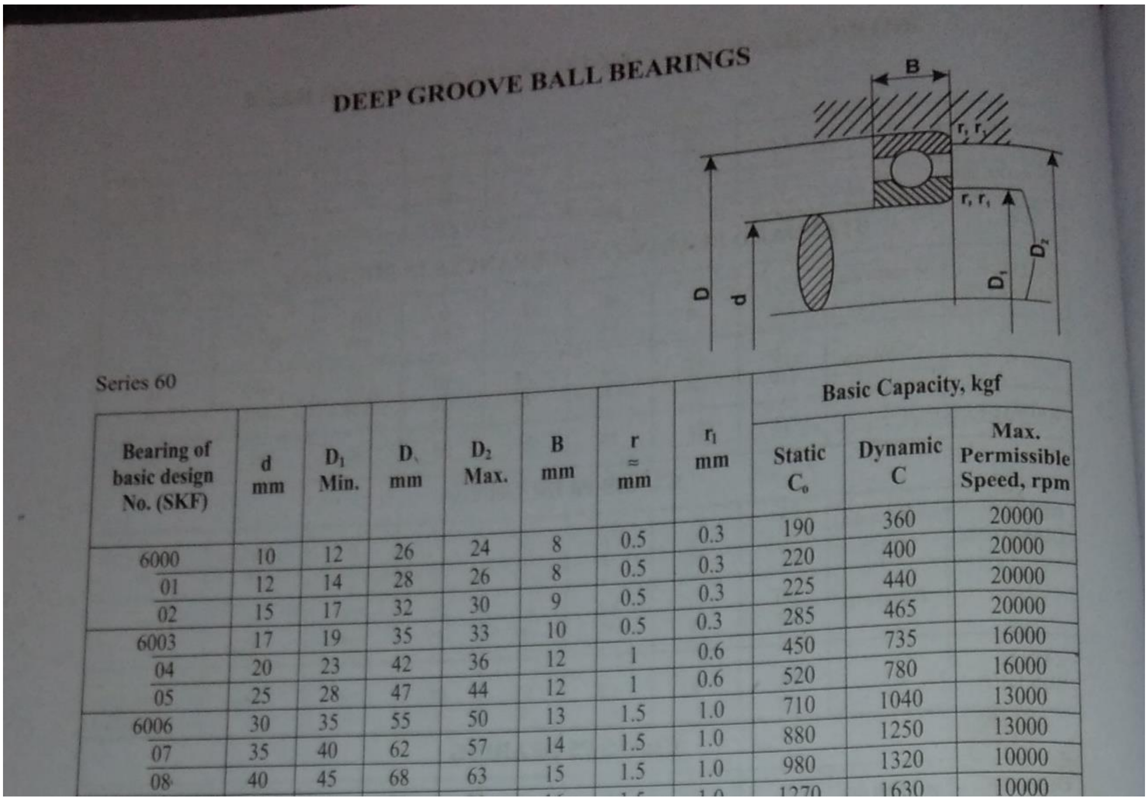
Fig. 7.13. Universal testing machine (UTM)

Fig. 7.14. Hinges hold in jaws of machine

Fig. 7.15. Failure of hinges

7.2.5 Selection of bearing

Bearing is designed for the shaft so that it can rotate freely. We had selected SKF 6004 bearing from PSG 4.12



DEEP GROOVE BALL BEARINGS

Series 60

Bearing of basic design No. (SKF)	d mm	D_1 Min.	D mm	D_2 Max.	B mm	r ≈ mm	r_1 mm	Basic Capacity, kgf Static C_o	Dynamic C	Max. Permissible Speed, rpm
6000	10	12	26	24	8	0.5	0.3	190	360	20000
01	12	14	28	26	8	0.5	0.3	220	400	20000
02	15	17	32	30	9	0.5	0.3	225	440	20000
6003	17	19	35	33	10	0.5	0.3	285	465	20000
04	20	23	42	36	12	1	0.6	450	735	16000
05	25	28	47	44	12	1	0.6	520	780	16000
6006	30	35	55	50	13	1.5	1.0	710	1040	13000
07	35	40	62	57	14	1.5	1.0	880	1250	13000
08	40	45	68	63	15	1.5	1.0	980	1320	10000
								1270	1630	10000

Fig. 7.16. Selected bearing from PSG (SKF 6004)

7.3 Bill of Materials

Material	Quantity	Price
Electric Linear Actuator	1	3505
MS Pipe (½inch 20mm thick)	20ft	262
MS Pipe (¾inch x ¾inch)	2pipe x 20 ft	516
Angle (25 x 3)	10ft	106
Angle (35x 5)	3ft	100
wheel with tube and tyre	2 pc	800
Castor wheel	2	600
Bearing SKF6004	4	320
Welding Rod	1 packet	190
Bearing hub shaft	2ft	100
Grinding and cutting wheel	7	200
Hinges	6pc	90
D.C Gear motor	2 pc	400
Red oxide	250 ml	40
G.P. Thinner	100 ml	20
Cushion and paint	-	1800
Total cost (Rs.)		**9049**

Chapter 8: Machine, tools and equipment used

8.1 Machines Used

Lathe Machine	Hand drill	Drilling Machine	Bench Grinder
Bench vice	Hand drill	Welding Machine	Circular Saw
Bend Saw	Universal Testing Machine	___	___

Table 8.1. Machines Used

8.2 Tools & Equipment used

Cutting Wheel	Grinding Wheel	Chuck key	Tool Post Key
Single point Cutting tool	Drill bit	Welding Rod	Plier
Screw Driver	Adjustable Spanner	Tapping tool	Boring tool
Right angle	Rough file	Smooth file	Centre Drill
Centre Support	Polish paper	Hammer	Goggle
Transparent tape	Mallet	___	___

Table 8.2. Tools and Equipment Used

8.3 Measuring instrument

Vernier Caliper	Metal Scale	Measuring Tape	Micrometer Gauge
Angle Gauge	Vernier Height Gauge	____	____

Table 8.3. Measuring Instruments Used

Chapter 9: Paint and Cushion work

9.1 Cushion work

When many wheelchair users think of a seat cushion, comfort comes to mind. However, a seat cushion provides benefits well beyond comfort, including pressure management and positioning that can reduce fatigue and enhance seated balance throughout the day. Surely, not everyone's positioning and sense of comfort is the same, so understanding cushion technologies is key to selecting the right cushion for you.

Seat Cushions are designed to offer:

- Comfort
- Pressure management
- Positioning
- Increased sitting stability

Indeed, there are many wheelchair cushions available - including foam, gel, and air technologies - and in understanding the benefits and limitations of each one, you can decide which is best for you. [7]

Cushion Varieties

- Foam Cushions
- Gel Cushions
- Air Cushions
- Other Cushion Resources

Tips for Selecting & Maintaining a Cushion

Foam Cushions

Foam cushions are the most basic cushion, ideal for those wishing simplicity at minimal cost. While some foam cushions are a single-density (firmness), others feature contoured bases with multiple layers of foam, designed for enhance pressure management and positioning. [7]

A foam cushion may be best for you if you need:

- Low maintenance
- Minimal cost
- A very stable seating surface
- Low to mid-range positioning
- Light weight

A foam cushion may not be best for you if you need:

- Exceptional pressure relief
- Advanced positioning characteristics

Gel Cushions

Gel cushions are specifically designed to optimize pressure relief by allowing one's pressure points to "immerse" into a gel pack, reducing pressure. Additionally, gel cushions typically feature a contoured base, with advanced positioning characteristics. [7]

A gel cushion may be best for you if you need:

- Optimal pressure relief
- Advanced positioning
- A very stable seating surface
- Low maintenance

A gel cushion may not be best for you if you need:

- Light weight
- Low cost

Air Cushions

As the name suggests, air cushions are filled with air, and by adjusting the air pressure, the cushion's firmness can be adjusted. Air cushions typically offer reduced stability and positioning by comparison to foam and gel cushions, but are exceptional in the area of pressure relief, allowing pressure points to "sink" into the cushion. Air cushions are commonly available in 2" and 4" heights, with the 2" offering a low-profile, more stable surface, and the 4" offering maximum pressure relief. [7]

An air cushion may be best for you if you need:

- Exceptional pressure relief
- Adjustable firmness
- Light weight
- Low maintenance

An air cushion may not be best for you if you need:

- Low maintenance (air cushions require regular monitoring of air pressure, and can develop leaks)
- Advanced positioning characteristics
- Utmost seating surface stability
- Low cost

Selecting & Maintaining a Cushion

A seat cushion's size should be matched exactly to the wheelchair's seat size Remember that a seat cushion's height adds to the wheelchair's seat-to-floor height, so a taller cushion will cause you to sit taller, accordingly (which can be an issue fitting under tables and desks)If there's a chance that the cushion will be exposed to fluids, an incontinence cover should be used (incontinence covers come included with many cushions)Inspect the cushion regularly for degraded materials or damaged foam With air cushions, confirm proper inflation daily Most cushions have an optimal use life span of two to three years, so for proper performance, replace a cushion when needed. [7]

9.2 Paint

To protect any metal from corrosion it is necessary to have some form of coating on it so the paint is the best way to coat it as well as aesthetic of structure is improved.

Fig. 9.1. Painted chassis

Chapter 10: Assembly of wheelchair

Hence all the three positions were achieved successfully which is shown in fig. below

Fig 10.1. : Assembly of wheelchair with all three positions

Chapter 10: Conclusion

Since patient has to depend on other for their daily life works So, our project 3 in 1 transforming wheelchair will serve the purpose to become independent and do their day to day works

Reference

[1] Wilson, A. Bennett, and Sameul R. McFarland. Wheelchairs: a prescription guide. Rehabilitation Press, 1986.

[2] Openshaw, Scott. “Allsteel and Erin Taylor.” Allsteel-Ergonomics and Design: A Reference Guide, Allsteel Inc. available at www.allsteeloffice.com (2006).

[3] Dempster, W.T. (1995). Space requirements of the seated operator: geometrical, kinematic, and mechanical aspects of the body, with special reference to the limbs.” (1995)

[4] A report in factsheet on wheelchair, WHO Oct 2010, WHO.

[5] Niu, Michael Chun-Yung. Composite airframe structure: practical design information and data. Adaso Adastra Engineering Center, 1992.

[6] Advani Oerlikam Handbook , “Guide on Selection of welding electrodes”.

[7] Mark E. Smith, “Spinlife guide to seat cushions”.

[8] C-Series, Table C-20, Data on Disability, Census of India 2001 and 2011