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A PROJECT REPORT

ON

"DESIGN, DEVELOPMENT OF SUSPENSION AND STEERING SYSTEM FOR FOUR WHEEL ELECTRIC SCOOTER FOR HANDICAPPED FOR INDOOR AND OUTDOOR USE"

Submitted by

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In fulfillment for the award of the Degree

Of

BACHELOR OF ENGINEERING

IN

MECHANICAL ENGINEERING

UNDER THE GUIDANCE

Of

Prof. Ziya Momin

DEPARTMENT OF MECHANICAL ENGINEERING

ANJUMAN-I-ISLAM

KALSEKAR TECHNICAL CAMPUS NEW PANVEL,

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UNIVERSITY OF MUMBAI

ACADEMIC YEAR 2020 -2021

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CERTIFICATE

Department of Mechanical Engineering
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2020-2021

This is to certify that the project entitled **Design, Development of Suspension and Steering for four wheel scooter for Handicapped for indoor and outdoor use** is a bonafide work of **Shaikh Mohammad Affan Salim (18DME45), Ansari Ruman Ahmed Rafeeque Ahmed (18DME36), Ansari Areeb Jamshid (18DME02), Mukri Umer Rashid (18DME26)** submitted to the University of Mumbai in fulfillment of the requirement for the award of the degree of Bachelor of Engineering in Department of Mechanical Engineering.

Supervisor

Examiner

Head of Department

Director

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Project Report Approval for Bachelor of Engineering

This project entitled **"Design, Development of Suspension and Steering system for four-wheel electric scooter for Handicapped for indoor and outdoor use"** by Shaikh Mohammad Affan Salim, Ansari Ruman Ahmed Rafeeque Ahmed, Ansari Areeb Jamshid, Mukri Umer Rashid are approved for the degree of **Bachelor of Engineering in Mechanical**.

Examiner

....

Supervisor

....

Date:

Place:

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Declaration

We declare that this written submission represents our ideas in our own words and where others ideas or words have been included, we have adequately cited and referenced the original sources. We also declare that we have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in our submission. We understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

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ABSTRACT

This report aims to the design, development and improvement of four-wheel electric scooter suspension and steering systems. The improvements in the existing project is made based on certain predefined problems and are considered in reference to the comfort of the handicapped. The maximum deflection is determined by performing static analysis and dynamic analysis. Moreover, it has been specifically designed for a particular patient who is disabled by lower limbs. Therefore, we have made it customized that is according to the patient body dimensions, needs or requirements.

As we had to customize this scooter so it can be used for indoor purpose also so keeping in mind, we had considered the comfort of the driver as our key motto and accordingly we researched on not only one but we considered three varieties of suspension.

All the impact and stresses were calculated manually by considering the severe working condition and then the design will be analyzed in the analysis software. Step by step modification in design we made as found necessary. After the complete analysis and the approval of design by inspecting it in all the modes of failure the design was finalized the suitable system.

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CHAPTER 1

INTRODUCTION

Disabled people and the elderly need to face their daily life just like normal people. But they need to be assisted by others to move back and forth. But it is not always possible for people to assist them all the time. By having a mobility scooter, they can move everywhere by themselves. Although nowadays there are many assistive mobility that exist for disabled people such as manual wheelchair but they may be reluctant to use because it makes them different from normal person. So, a trendy look like scooter can increase their confidence to mingle like a normal person. Assistive and small sit-down motor scooters provide important advantages to people with mobility problem throughout the world. Scooters are a subclass of motorcycles and are very popular as urban and rural means of transportation. There are several types of scooters that we will find zooming up and down the highways and city streets. A scooter is also useful for person without the stamina or arm flexibility necessary to use a manual wheelchair. Swiveling the seat of an electric scooter is generally easier than moving the foot supports on most conventional wheelchairs. A mobility scooter is very helpful for persons with systemic or whole-body disabling conditions.

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1.1 Problem Statement

The main purpose of this scooter is to make a disabled or aged person to be self-dependent. Mobility scooters are famous and available in foreign markets but in India there are no manufacturers of mobility scooter and so only few suppliers are available. And since it is imported it becomes costly and most of the people can't afford to buy it. Therefore scooters that are available with suppliers are expensive and not according to Indian roads (friction between tire and road, speed, shock absorber and many other factors).So we have designed it In such a way that it becomes feasible without compromising the actual need of the disabled person which includes comfort, speed, reliability, aesthetic appeal and is according to Indian roads.

Following are the main problems that are identified and are to be overcome:

- Suspension is causing over weight. We need to find the suspension used in Real electric vehicles (Same implies to rear suspension) and accordingly find the Steering with respect to it.
- To entirely change the chassis design.
- To only use BLDC motor to transmit power to rear wheels instead of hub motor.
- Currently the weight of the vehicle is 230 Kg. and chassis is 158 kg in particular We need to reduce it at least by 50Kg.

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CHAPTER 2

Literature Review

2.1 Literature Review

According to a survey done by WHO it was found that around 7 lac accidents occur every year in India. Out of these 2.3 lac people becomes permanently disabled. Out of these permanently disabled peoples around 50% are disabled by lower limbs. The person with such a disability are laid on the bed for rest of their life. They cannot take part in any social activity. They are dependent on others for their needs. As time passes by they are isolated by the society. Due to which they start feeling lonely, and eventually results in the death of the disabled person due to depression. This can be avoided by bringing them to their social life. In order to overcome this problem, the solution is a mobility scooter which can be used by the disabled person not only for outdoor purpose but also for indoor. This mobility scooter will help them to return to normal life. It will also make them independent.

An electric scooter is a battery-operated one-person capacity vehicle that is specially designed for people with low mobility. It is generally used by those who have difficulty walking or standing for long periods of time. Scooters are available in three common designs, those intended for indoor use, those for outdoor use, and those that are used for both. An electric scooter is different from a motorized wheelchair, in that the wheelchair is generally intended for indoor use and usually costs a great deal more. Some people are a little wary of purchasing an electric scooter because they fear it will be difficult to operate. In fact, the control console makes it quite simple once a person gets the feel for it.

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2.2 Scooter Operation

Generally, there is several types of scooter. The way how to produce power for this kind of transport is depend on its want to use. High power scoter usually use small engine with gasoline. Another type is using electric motor operation whether dc or ac motor. This kind of bike usually use in small area and for recreation.

2.2.1 Engine Powered Scooter:

This type of scooter usually uses small capacity engine. Normally around 40 to 60 cubic capacities (cc). This kind of engine can be found whether four-stroke or two stroke engines. This small engine scooter usually looks like small super bike. It can speed up until 50 to 60 km/h. Safety clothes should be used for precaution safety while ride this type of bike. This kind of scooter usually can be found at place which already has their club track. The sound of this bike is little bit noise but it looks very nice.

2.2.1 Electric Motor Scooter:

Generally, the source of power for the electric motor has been batteries, but development in fuel cell technology has created several prototypes. Some examples are: the ENV from Intelligent Energy, Honda's scooter using the Honda FC Stack, and the Yamaha FC- AQEL. Also, petroleum hybrid-electric motorcycles are under development. Some examples are the E-cycle, and Yamaha's Gen-RYU. Figure 2.3 is example of scooter using electric motor with stand riding operation.

2.2.1 Mobility Scooters:

This is a modified version of the electric scooter and is made for special people like the disabled and the aged people. These scooters are extremely stable, as they have more than two wheel or four wheels.

CHAPTER 3

Methodology

3.1 Methodology

Flow of our work is as follows:

1. Literature Review

a. Make review on other model and type of scooters

b. Focusing on how to make it simple and relevance to the project title.

2. Design Calculation

c. Calculation of torque and power required to drive the vehicle.

3. Market Survey

d. As per our design calculation we visited few suppliers and as per the availability and cost – Suspension and Steering mechanism selection is done.

4. Modification Design

e. As per the parts available the design has been modified

f. The 18-inch Tie rod in the Ackerman's steering is been changed.

g. Detailed design of front & rear suspensions with wishbone type system.

h. Modification in rear suspension by introducing 'trailing arm'.

5. Analysis

i. Analysis of Wishbone, Trailing arm and the Tie rod with the assistance of ANSYS software.

6. Documentation

j. Preparation of detailed report for the project.

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CHAPTER 4

Troubleshooting

4.1 Suspension System

- **Problem:**

  Suspension is causing over weight. We need to find the suspension used in Real electric vehicles (Same implies to rear suspension) and accordingly find the Steering with respect to it.

In the previous design the four-wheel electric scooter was directly been employed with the conventional suspension mechanism of the Honda Activa that is more rigid but as far as the comfort of the handicapped is concerned it goes inversely with it, Also the use of conventional suspension mechanism caused the overweight of the vehicle that leads to discomfort.

Hence the only solution of the trouble is to go on with the improvement in the existing design by replacing the conventional suspension system with the more suitable mechanism of suspension.

Hence, instead of going for only solution we decided to do a market survey and looked into the details three of most effective suspension systems on the basis of their optimality, availability, cost etc.

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4.1.1 Electromagnetic Regenerative Suspension

Introduction:

As the depletion of oil resources and increasing greenhouse effects, methods to save resources and reduce CO_2 emissions are attracting significant attention. The transportation sector is the second-largest source of CO_2 emissions, which are primarily produced by gasoline, diesel, heavy oils, and jet fuel, consuming approximately 27% of total world main energy. Consequently, reducing energy consumption, fully utilizing energy, and recovering potential energy in the transportation sector are of great significance. Electric vehicles (EVs) have gained increasing popularity due to lower energy consumption and reduced pollution. The adoption of EVs around the world can effectively alleviate the problems above. However, based on the unsatisfactory specific capacity of batteries and considerations for reliability, the application of EVs is hindered by their extremely limited range, which hits a significant bottleneck. When driving an electric vehicle, most people are concerned about endurance mileage, which typically leads to mental distress or uneasiness. There are two main methods to alleviate the problems in EVs. The first method focuses on the external factors of EVs, such as utilizing a faster and more convenient charging technology, formulating battery-management strategies and selecting optimal charging station locations. Although these general measures can extend the range of EVs by improving external conditions to break the aforementioned bottleneck, they cannot be long-term solutions if the principal internal issues are not solved. The second method pays more attention to wasted energy harvesting, including braking energy, vibration energy and other kinds of energy. For example, the vehicle cabin can be cooled by recycling solar energy, Qi used phase-change materials to cool the carbine. Abdel Hamid modelled the comprehensive on-board photovoltaic system for plug-in EV. Another prevailing method is recycling energy through piezoelectric materials from tire deformations. Maurya harvest strain energy from the automobile tires. Power output of similar to 580 μW at 16 Hz. Qian proposed an on-vehicle magnetically triboelectric Nano generator for tire pressure monitoring systems. The above solutions have been given focus in recent years especially the regenerative suspension. When vehicles drive on rough roads or change speeds, the shock absorbers installed in their suspension systems are compressed and stretched. Consequently, vibration energy will be dissipated in the form of heat. In terms of ease of installation, energy density and recovery efficiency, vibration energy recovery is one of the most efficient energy recovery methods and is widely utilized in commercial applications to

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recover energy to power batteries. Researches on vibration energy recovery in shock absorbers have been ongoing for decades.

System design:

The general structure of the regenerative shock absorber considering twin ball screws transmissions is presented in Fig. 1. The proposed system consists of four main modules: the suspension vibration input module, transmission mechanism module, generator module, and power storage module. As shown in the left portion of Fig. 1, when a vehicle is passing over an uneven road or changing speed, reciprocating linear vibrations from the two cylinders are inputted into the shock absorber, resulting in the nuts traveling downward or upward through the rods. The assembly of the cylinders, rods, and nuts is defined as the suspension vibration input module. As shown in Fig. 2, the transmission mechanism module transforms the reciprocating vibrations into unidirectional rotation of the generator shaft by utilizing a pair of ball screws with different rotation directions and screw pitches, a pair of overrun clutches, and gear mechanism. The generator module converts the mechanical energy of the unidirectional rotating shaft into electricity, which increases the efficiency of energy harvesting and reliability of the entire system. The energy is stored in the power storage module in super capacitors, which are utilized to charge the batteries of EVs, as shown in the right portion of Fig 1.1.

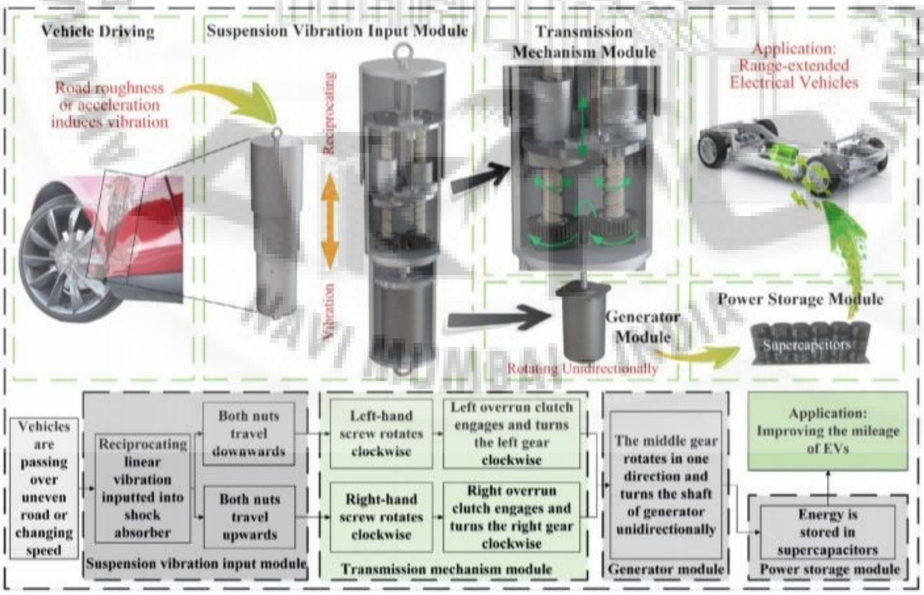

Fig: 1.1

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Fig. 2. Structure of the regenerative shock absorber.

Fig 1.2

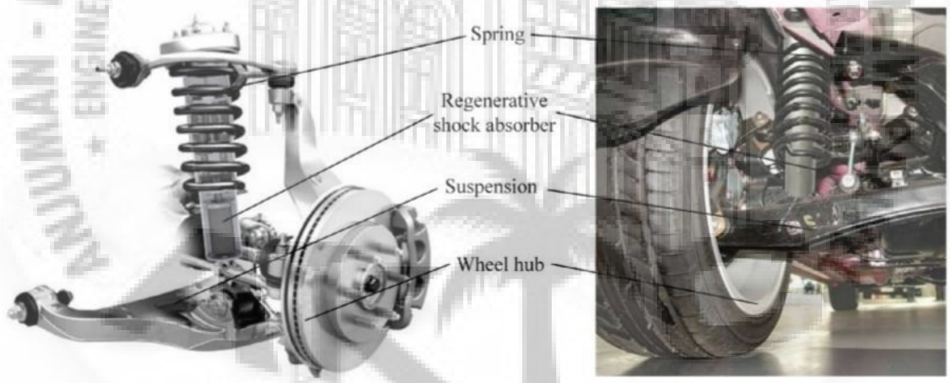

Fig. 3. Installation diagram of the energy regenerative shock absorber.

Fig 1.3

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Future recommendations:

There is much more work to be done in the future. The suggestions can be summarized as follows:

(1) The ratio of the screw leads can be adjusted to meet the different requirement of damping ratio between stretching and compression progress, which can obtain a superior shock absorption effect and better ride comfort.

(2) How to reduce the electricity loss caused by the voltage regulator which can adjust the generator output voltage and stabilize the power load should be further studied in the future.

(3) In the MTS bench tests, the value of the external resistors is selected theoretically as 3 Ω for obtaining the required damping coefficient according to the linear damping coefficient of the prototype in Fig. 11. While the regenerative shock absorber with different values of the external resistors will be tested in the MTS experiment in order to investigate the practical mechanical feedback and performance.

(4) The commercialization process of the proposed regenerative shock absorber needs to be paid attention to reduce costs, improve performance, find investors and sales targets, such as the manufacturers of EV, formulate complete business plan and sell invention patents in the future. The methods for reducing costs include using standard parts, batch production and so on. Adopting the 1st–4th suggestions may be conducive for improving performance.

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4.1.2 Magnetic Suspension System

Introduction:

At present, most of the two-wheeler are using a passive hydraulic suspension. One of the main features of hydraulic suspension is it uses hydraulic oil as a damper. Whenever a vehicle experiences road irregularity, the excitation force from road surface is absorbed by the damper. The absorbed energy is converted into heat inside the damper. The vehicle body weight is supported by the mechanical spring attached with the damper. However, there are some disadvantages of hydraulic system. According to Gysen, hydraulic damper contributes to environmental pollution due to hose leaks and ruptures, where hydraulic fluids are toxic. Then, the hydraulic systems are considered inefficient due to the required continuously pressurized system. On the contrary, magnetic suspension systems (MS) not require hydraulic fluid. It consists two magnets and two springs. one magnet and spring is attached to the chassis and another spring and magnet is connected to the road wheels. Basically, faradays law of electromagnetic invention is main supportive law for that also, everyone knows about maglev train one of the best invention today's modern technology and maglev train works on the magnetic levitation and easily maintained gap between track and railway. Same concept using for electromagnet suspension electromagnetic suspension system due to it have a relatively high force density that can control the vehicle body vibration same as hydraulic damper.

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Methodology:

In two-wheelers suspension system is used coil spring but the limitation of that coil spring is that after some period of time it becomes not only harder but also reduced cushioning effect. This limitation is overcome by magnetic suspension. The cushioning effect provide by magnetic suspension is existing for long time. Unlike poles of a magnet attract each other and like poles repel each other. When we place two north pole or south poles facing each other and when they are brought closer, they are repelled. this concept is used in magnetic suspension .in this suspension a set of magnets have been selected like poles then one magnet is fixed at chassis and another magnet is placed at road wheel. When two magnets are brought closer to each other they are repelled due to similar polarity and the aspect of suspension is achieved.

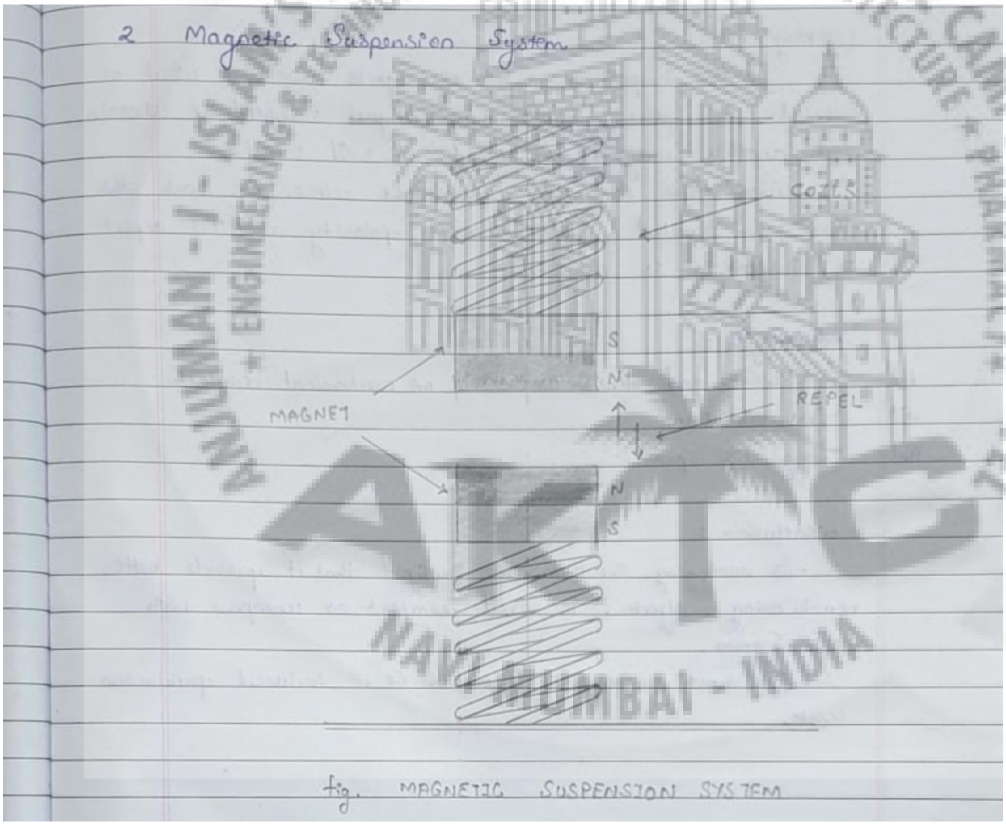

Fig 1.4

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Design of Magnet:

The magnet we are using here is permanent type magnet which has following properties.

- Power of magnet pair = 10000 Gauss power
- Weight = 0.5 Kg …. [9]

Advantages:

A. Less wear and tear as there is no mechanical contact

B. Simple design

C. Less vibrations

D. Long life span

E. Reliable

F. It reduces energy consumption

G. Largely obviating friction

As analyzing the data, we realized that it provides better cushioning effect, increased comfort as compare with other system. In the conventional damping system, the kinetic energy is converting into heat of oil but in this case unnecessary moment of damper is take place this is totally avoid in above invention. It is not as much of expensive so it reduced production cost.

4.1.3 Adjustable Suspension

Introduction:

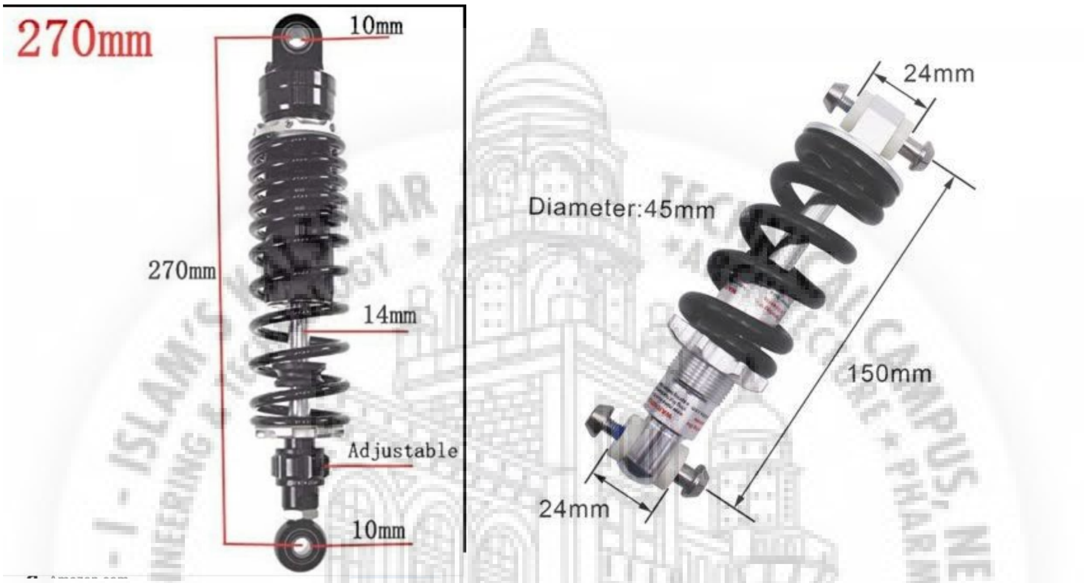

Fig: 1.3.1

Stiffer shocks give a more responsive feel when you want the car to change direction, but the compromise is a harder ride quality, Adjustable shocks are a way to get around this by the processes 1) Letting less oil through means stiffer shocks, 2) letting more oil go through means less damping and a softer ride.

Conclusion: Its concluded that the most efficient and economical suspension to use is Adjustable shock absorbers with different dimensions in both front & rear side.

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4.1.4 Design of Suspension system

a) Shock absorbers:

In the design of suspension system, firstly we designed the model of both front and rear shock absorbers that are selected as 'Adjustable shock absorber' on the Autodesk inventor software that are having following dimension details and empirical data.

Front shock absorber:

length = 6.1' (center to center mounting)

Material = steel

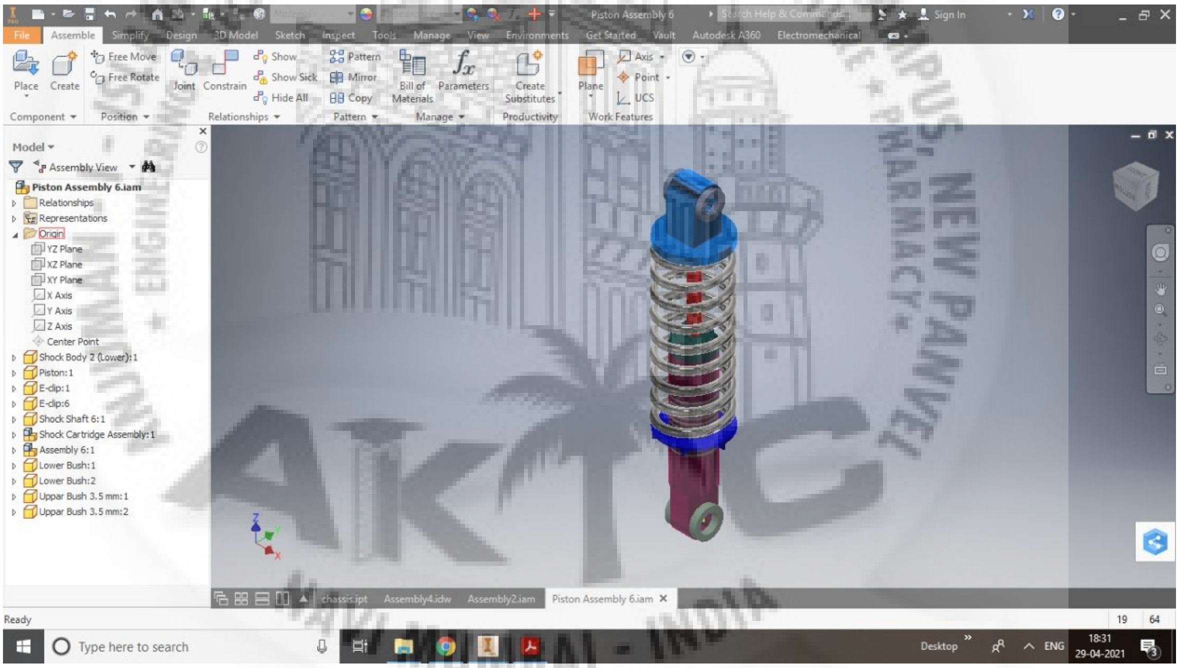

Fig: 1.4.1 Front adjustable shock absorber

Rear shock absorber:

Length = 10.3' (center to center mounting)

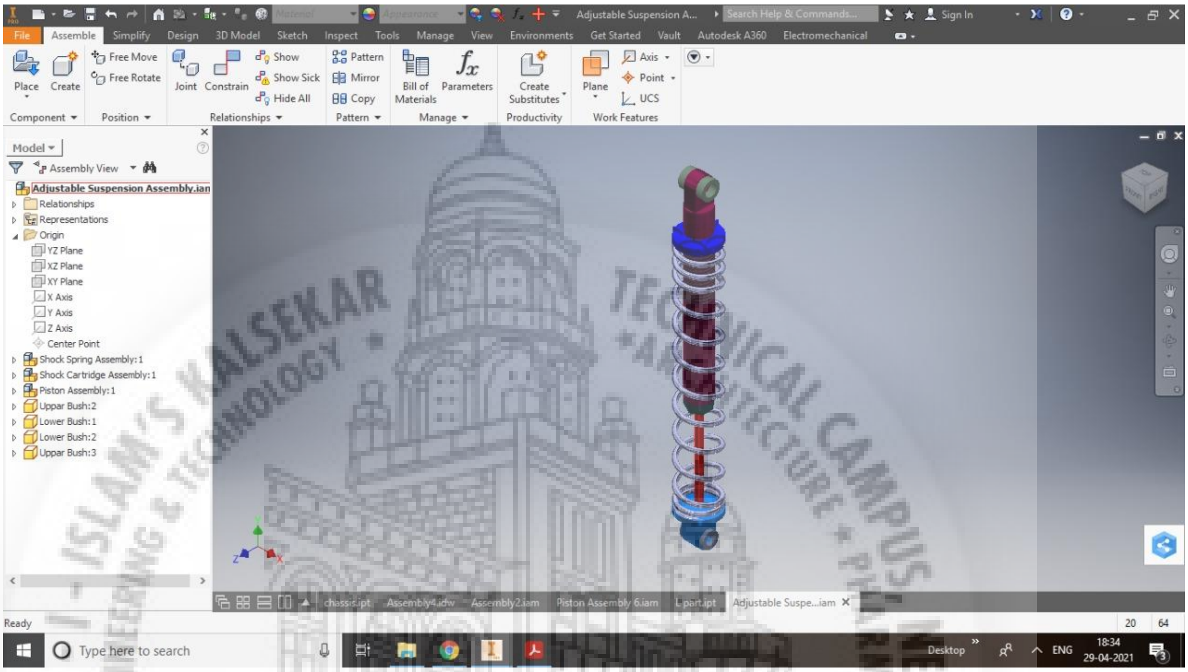

Fig: 1.4.2 Rear adjustable shock absorber

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Front suspension system:

b) Double Wishbone suspension system:

Double wishbone suspension is an independent suspension design using two (occasionally parallel) wishbone -shaped arms to locate the wheel. Each wishbone or arm has two mounting points to the chassis and one joint at the knuckle. The shock absorber and coil spring mount to the wishbones to control vertical movement. Double wishbone designs allow the engineer to carefully control the motion of the wheel throughout suspension travel, controlling such parameters as caster and camber angles, toe pattern, roll center height, scrub radius**.**

Lower and upper arm of wishbone:

Material = chromoly (chromium + molybdenum steel) AISI 4130

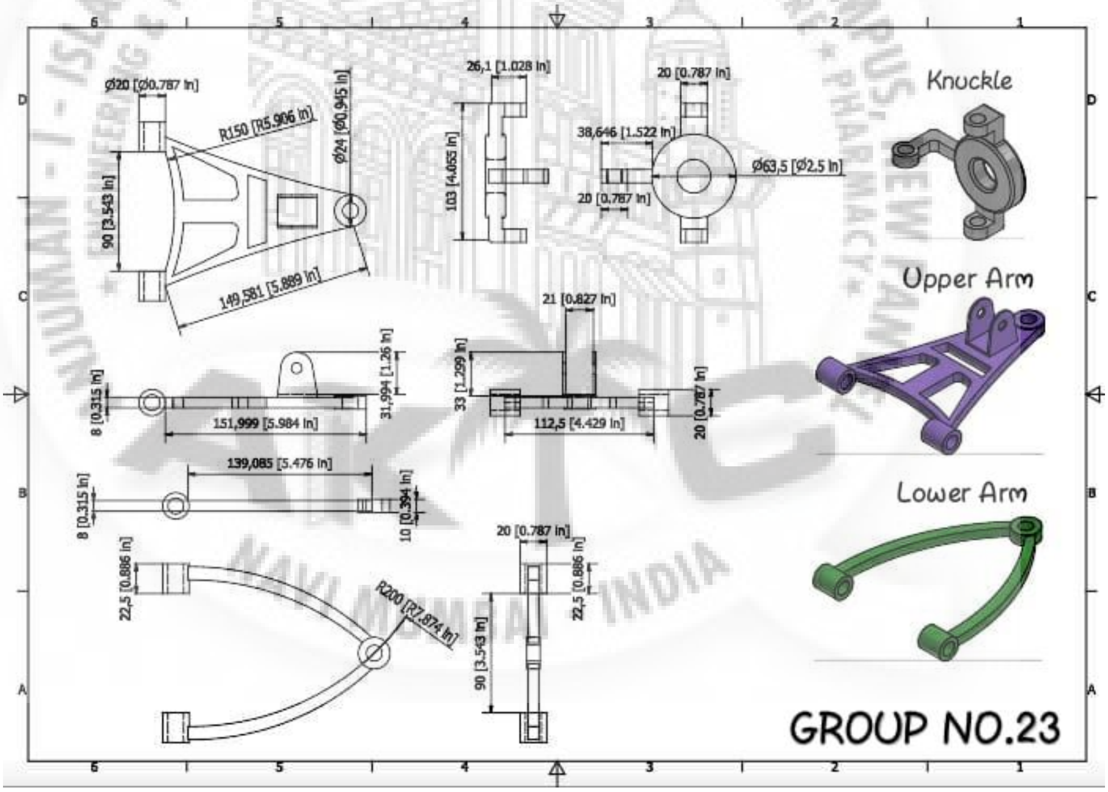

Fig: 2.4.1

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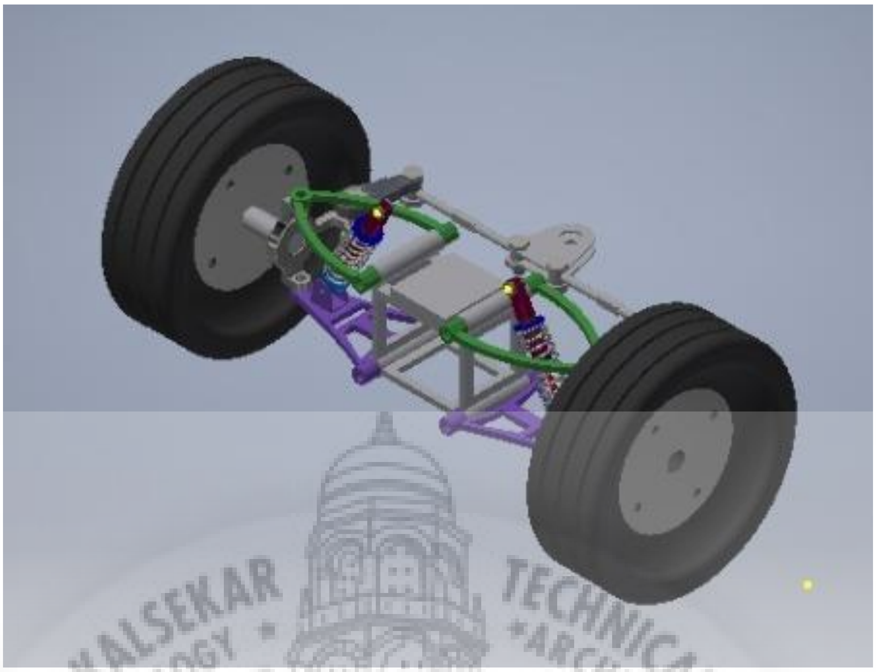


Fig: 2.4.2

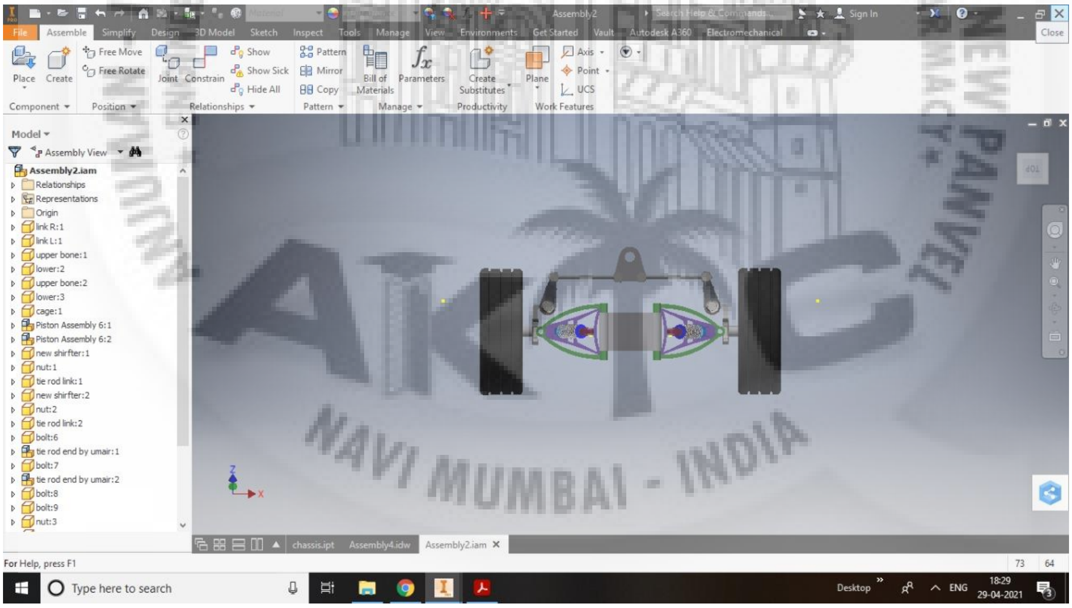


Fig: 2.4.3

Rear suspension system:

c) Design of trailing arm:

This trailing arm is designed for the mounting of the rear adjustable shock absorber, it is arranged in such a way that it will be connected with the shock absorber to its lower end and upper end of shock absorber is connected to the chassis.

In the existing model there was a bulky frame structure that used a U type structure, we replaced it with the trailing arm which will make the suspension more comfortable and the cushioning will be there for the handicap which will make him feel comfortable.

Although there was a problem with the trailing arm that after removing the U type frame it won't assist it in the independent suspension, so we rectified this problem by making an arrangement of the CV point on both of the sides of the rear axle wheels.

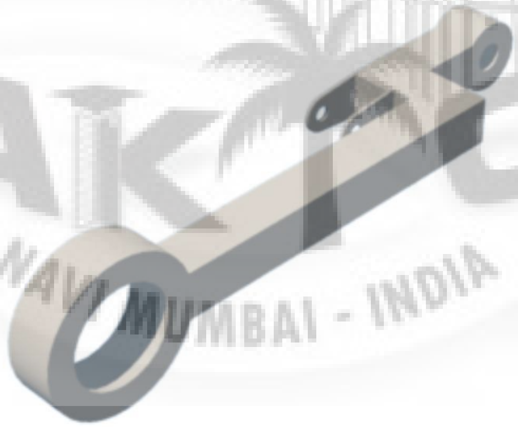


Fig: 3.4.1 Trailing arm

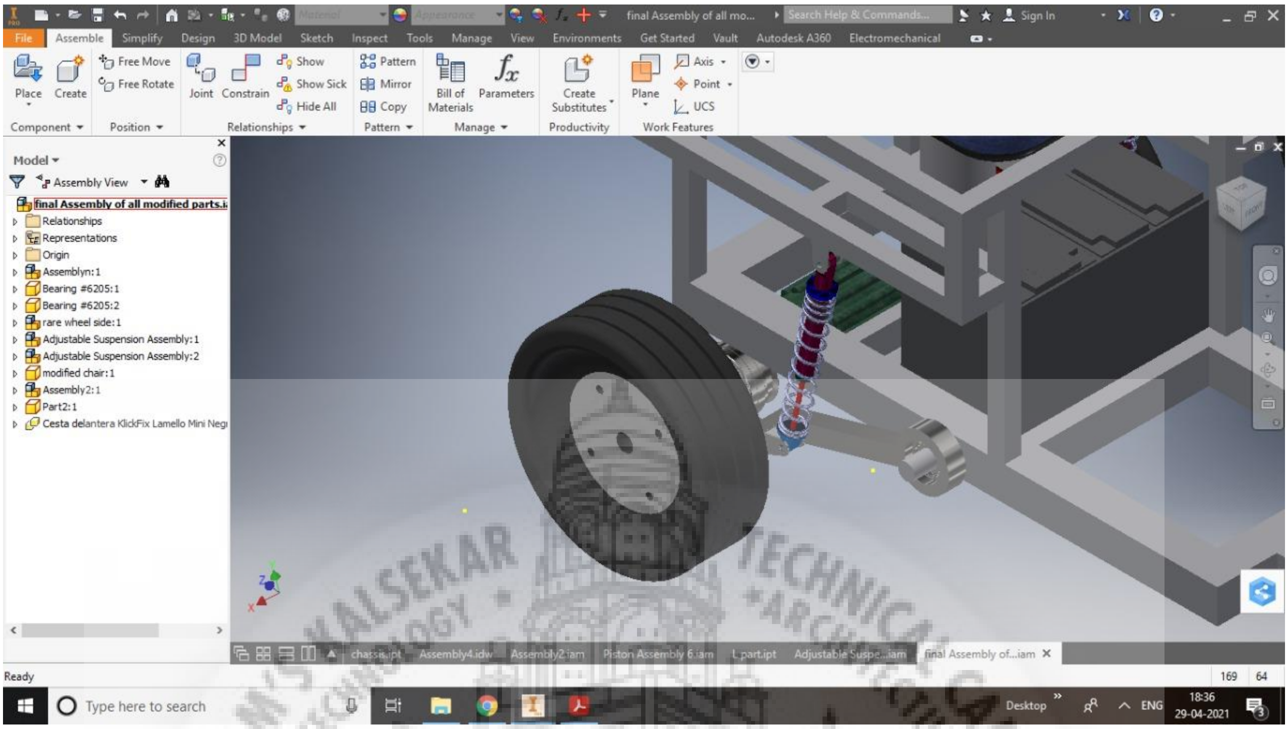
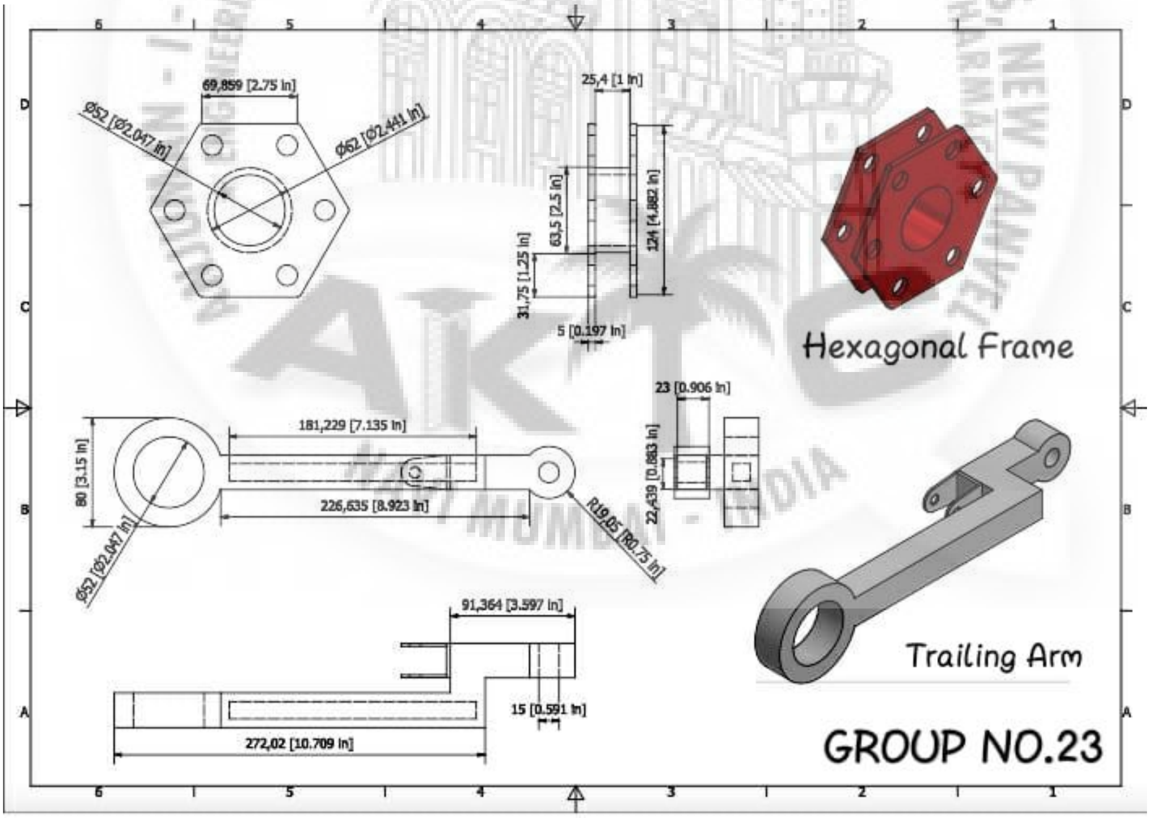

final Assembly of all modified parts
Relationships
Representations
Origin
Assemblyn:1
Bearing #6205:1
Bearing #6205:2
rare wheel side:1
Adjustable Suspension Assembly:1
Adjustable Suspension Assembly:2
modified chair:1
Assembly2:1
Part2:1
Ready

Fig: 3.4.2


69,859 [2.75 in]
Ø52 [Ø2.047 in]
Ø62 [Ø2.441 in]
25,4 [1 in]
63,5 [2.5 in]
124 [4.882 in]
31,75 [1.25 in]
5 [0.197 in]
Hexagonal Frame
23 [0.906 in]
22,439 [0.883 in]
80 [3.15 in]
181,229 [7.135 in]
226,635 [8.923 in]
R19,05 [R0.75 in]
Ø52 [Ø2.047 in]
91,364 [3.597 in]
15 [0.591 in]
272,02 [10.709 in]
Trailing Arm
GROUP NO.23

4.1.5 Structural Analysis

a. Shock Absorber:

Structural Analysis using Spring Steel as spring material,

Material: Spring Steel
Material Properties:
Young"s Modulus (EX): 202000
Poisson"s Ratio (PRXY): 0.292
Density: 0.000007820kg/mm3

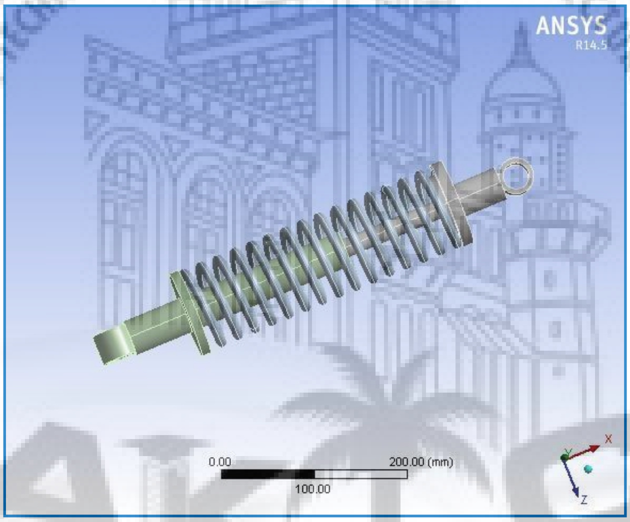


Fig 4.1.1: Imported model from Pro/Engineer

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i. **Meshed Model**

Fig 4.1.2: Meshed model

ii. **Load applied on model**

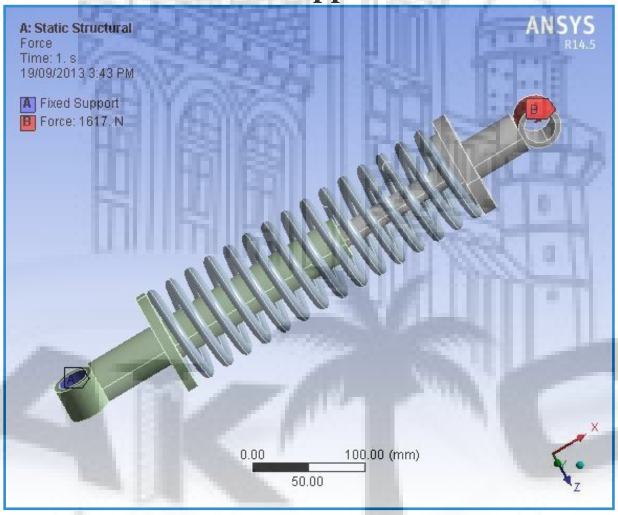

Fig 4.1.3: Load applied on model

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1. Results after applying load:

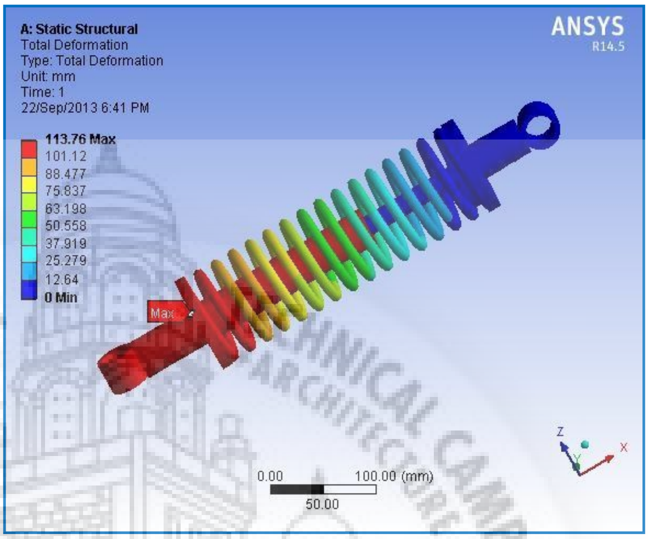

Fig 4.1.4: Total Deformation

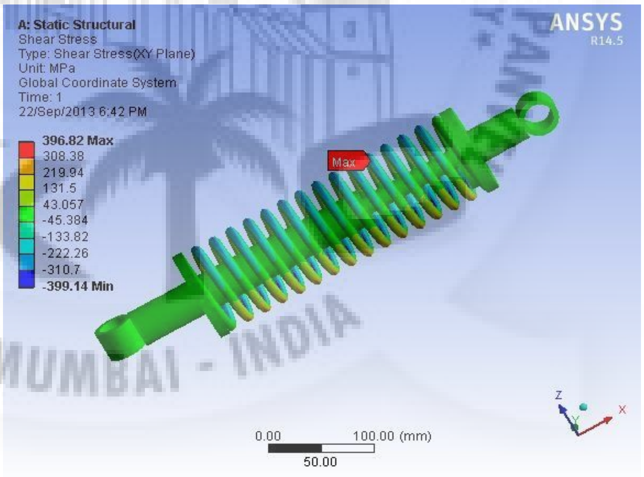

Fig 4.1.5: shear stress

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Result table

	Analytical	Spring Steel
Total Deformation(mm)	111.98	113.76
Shear Stress (N\mm^2)	364	396.82
Natural Frequency		3.0055
		3.0098
		11.113
		12.873
		12.896
		17.200

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b. Double Wishbone Suspension (Lower arm):

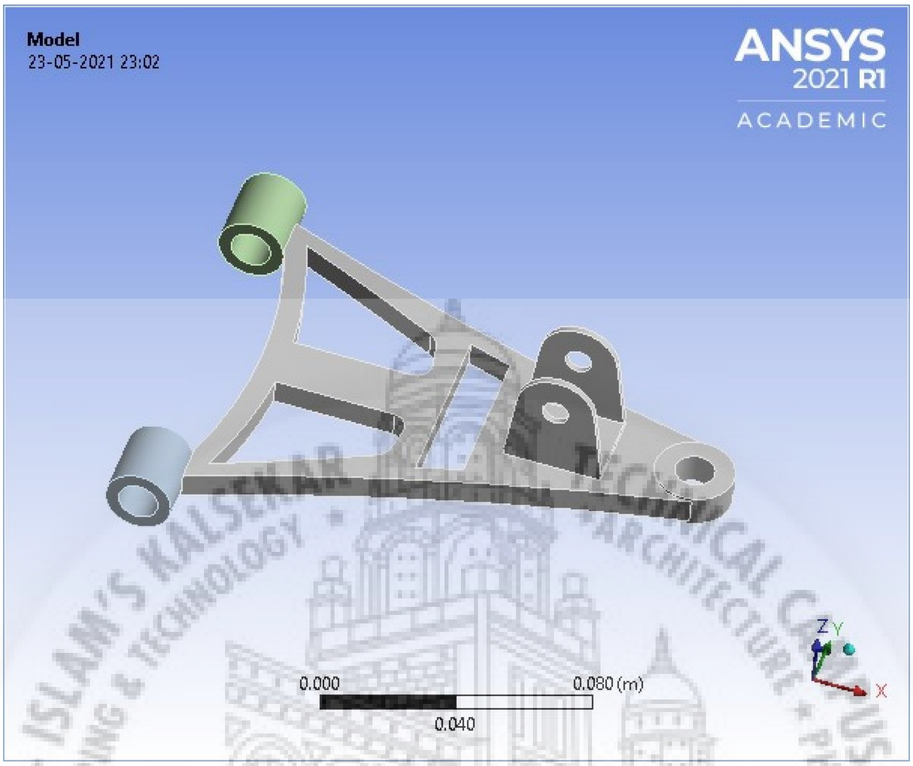

Fig 1.5.1: Lower Wishbone arm

Units:

TABLE 1

Unit System	Metric (m, kg, N, s, V, A) Degrees rad/s Celsius
Angle	Degrees
Rotational Velocity	rad/s
Temperature	Celsius

TABLE 2
Model (A4) > Static Structural (A5) > Solution (A6) > Results

Object Name	*Total Deformation*	*Equivalent Stress*	*Maximum Principal Stress*
State	Solved		
Scope			
Scoping Method	Geometry Selection		
Geometry	All Bodies		
Definition			
Type	Total Deformation	Equivalent (von-Mises) Stress	Maximum Principal Stress
By	Time		
Display Time	Last		
Calculate Time History	Yes		
Identifier			
Suppressed	No		
Results			
Minimum	0. m	0. Pa	-3.0464e+007 Pa
Maximum	1.171e-003 m	1.5803e+008 Pa	1.5425e+008 Pa
Average	4.6072e-004 m	3.9335e+006 Pa	1.9545e+006 Pa
Minimum Occurs On	SYS\Solid2	SYS\Solid3	SYS\Solid1
Maximum Occurs On	SYS\Solid1		
Information			
Time	1. s		
Load Step	1		
Substep	1		
Iteration Number	1		
Integration Point Results			
Display Option		Averaged	
Average Across Bodies		No	

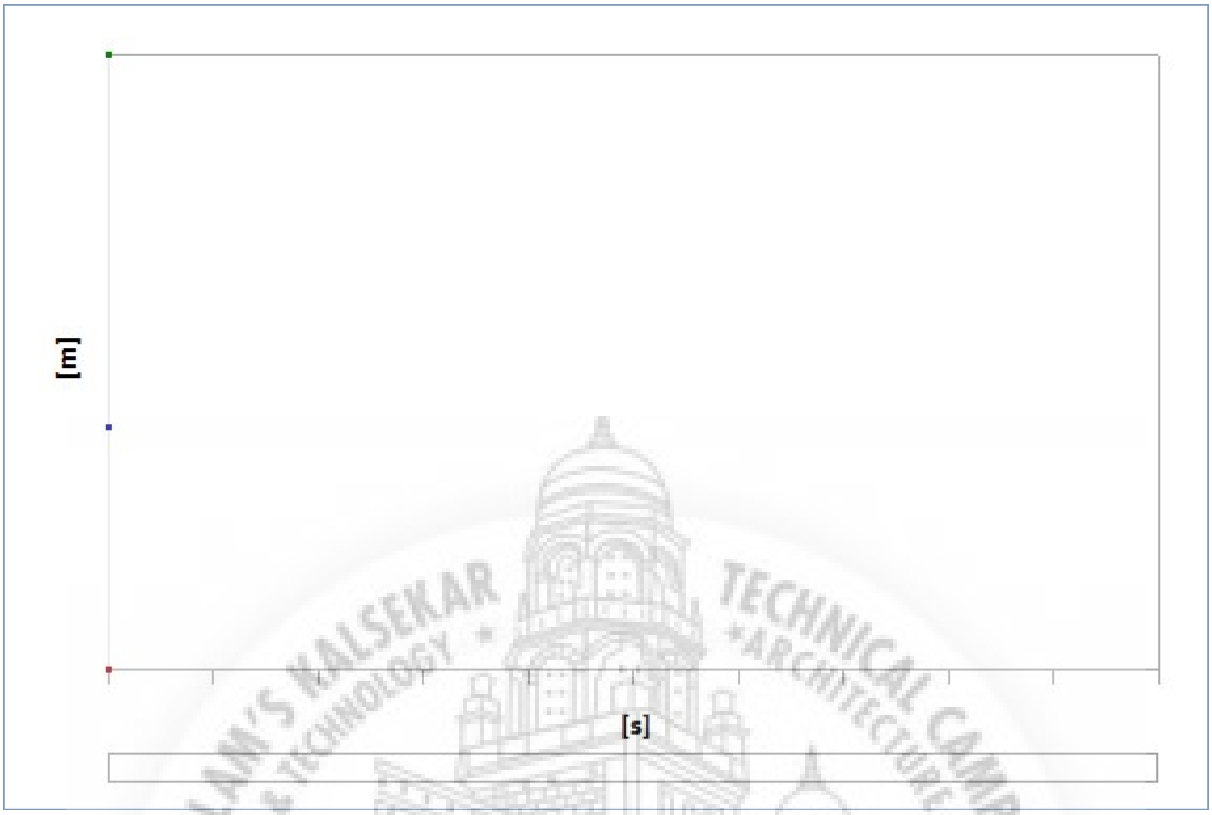

Fig 1.5.3
Model (A4) > Static Structural (A5) > Solution (A6) > Total Deformation

TABLE 16
Model (A4) > Static Structural (A5) > Solution (A6) > Total Deformation

Time [s]	Minimum [m]	Maximum [m]	Average [m]
1.	0.	1.171e-003	4.6072e-004

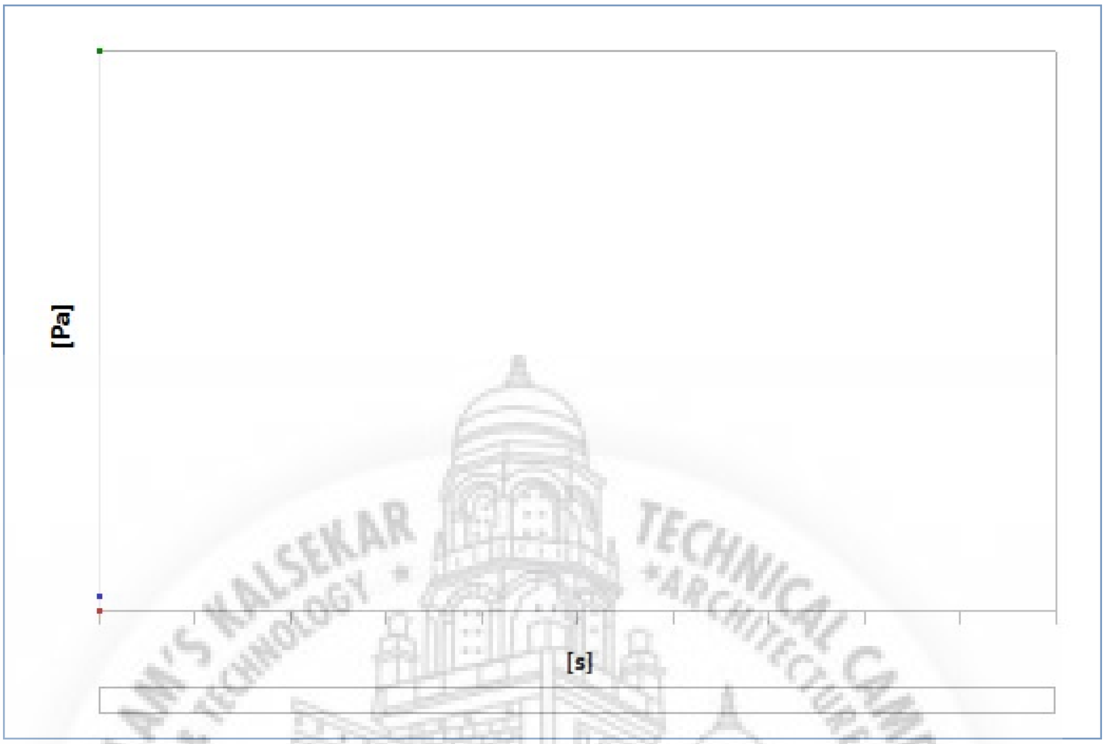

Fig 1.5.4:
Model (A4) > Static Structural (A5) > Solution (A6) > Equivalent Stress

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

Time [s]	Minimum [Pa]	Maximum [Pa]	Average [Pa]
1.	0.	1.5803e+008	3.9335e+006

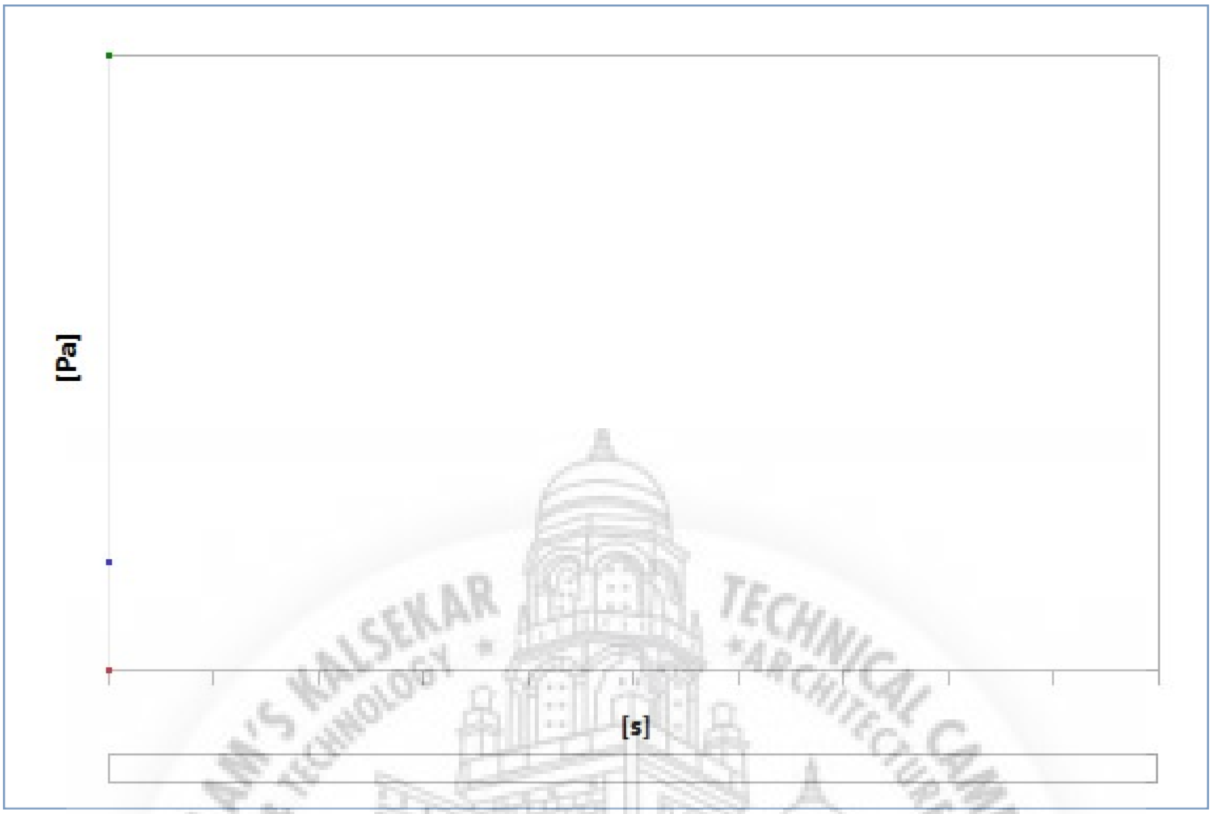

Fig 5.1.5:
Model (A4) > Static Structural (A5) > Solution (A6) > Maximum Principal Stress

TABLE 18
Model (A4) > Static Structural (A5) > Solution (A6) > Maximum Principal Stress

Time [s]	Minimum [Pa]	Maximum [Pa]	Average [Pa]
1.	-3.0464e+007	1.5425e+008	1.9545e+006

Total Deformation:

TABLE 19
Model (A4) > Static Structural (A5) > Solution (A6) > Total Deformation > Results

Object Name	*Total Deformation 2*
State	Not Solved
Scope	
Scoping Method	Geometry Selection
Geometry	All Bodies
Definition	
Type	Total Deformation
By	Result Set
Set Number	1.
Calculate Time History	Yes
Identifier	
Suppressed	No
Results	
Minimum	
Maximum	
Average	
Minimum Occurs On	
Maximum Occurs On	
Time	
Load Step	0
Sub step	0

Material Data:

AISI 4130

TABLE 20
AISI 4130 > Constants

Density	7850 kg m^-3
Coefficient of Thermal Expansion	1.2e-005 C^-1
Specific Heat	434 J kg^-1 C^-1
Thermal Conductivity	60.5 W m^-1 C^-1
Resistivity	1.7e-007-ohm m

TABLE 21
AISI 4130 > Color

Red	Green	Blue
132	139	179

TABLE 22
AISI 4130 > Compressive Ultimate Strength

Compressive Ultimate Strength Pa
0

TABLE 23
AISI 4130 > Compressive Yield Strength

Compressive Yield Strength Pa
2.5e+008

TABLE 24
AISI 4130 > Tensile Yield Strength

Tensile Yield Strength Pa
4.6e+008

TABLE 25
AISI 4130 > Tensile Ultimate Strength

Tensile Ultimate Strength Pa
5.6e+008

TABLE 26
AISI 4130 > Isotropic Secant Coefficient of Thermal Expansion

Zero-Thermal-Strain Reference Temperature C
22

TABLE 27
AISI 4130 > S-N Curve

Alternating Stress Pa	Cycles	Mean Stress Pa
3.999e+009	10	0
2.827e+009	20	0
1.896e+009	50	0
1.413e+009	100	0
1.069e+009	200	0
4.41e+008	2000	0
2.62e+008	10000	0
2.14e+008	20000	0
1.38e+008	1.e+005	0
1.14e+008	2.e+005	0
8.62e+007	1.e+006	0

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TABLE 28
AISI 4130 > Strain-Life Parameters

Strength Coefficient Pa	Strength Exponent	Ductility Coefficient	Ductility Exponent	Cyclic Strength Coefficient Pa	Cyclic Strain Hardening Exponent
9.2e+008	-0.106	0.213	-0.47	1.e+009	0.2

TABLE 29
AISI 4130 > Isotropic Elasticity

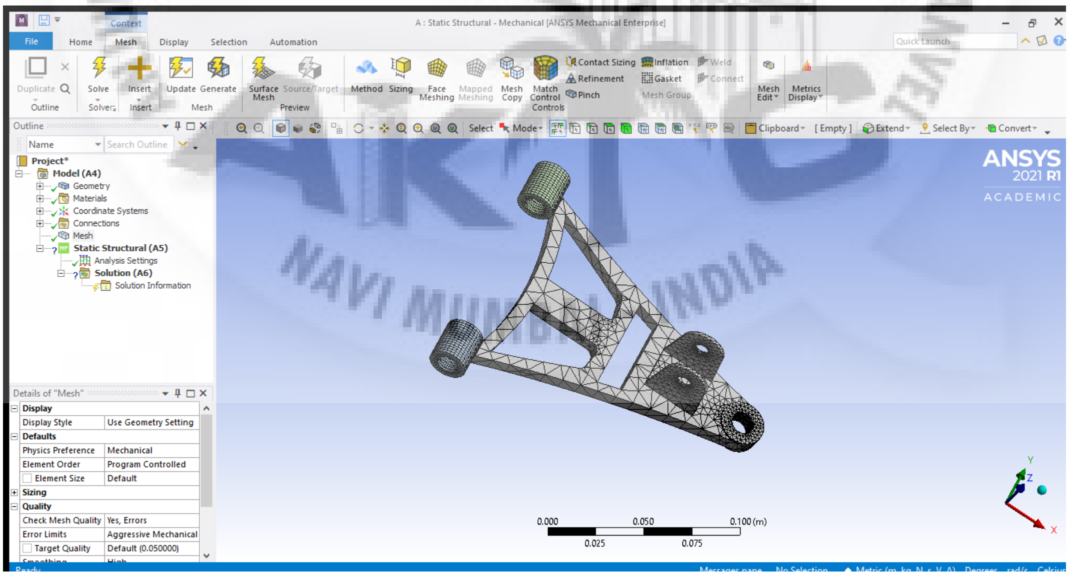
Young's Modulus Pa	Poisson's Ratio	Bulk Modulus Pa	Shear Modulus Pa	Temperature C
2.016e+011	0.26	1.4e+011	8.e+010	

TABLE 30
AISI 4130 > Isotropic Relative Permeability

Relative Permeability
10000

TABLE 31
AISI 4130 > Melting Temperature

Melting Temperature C
1432



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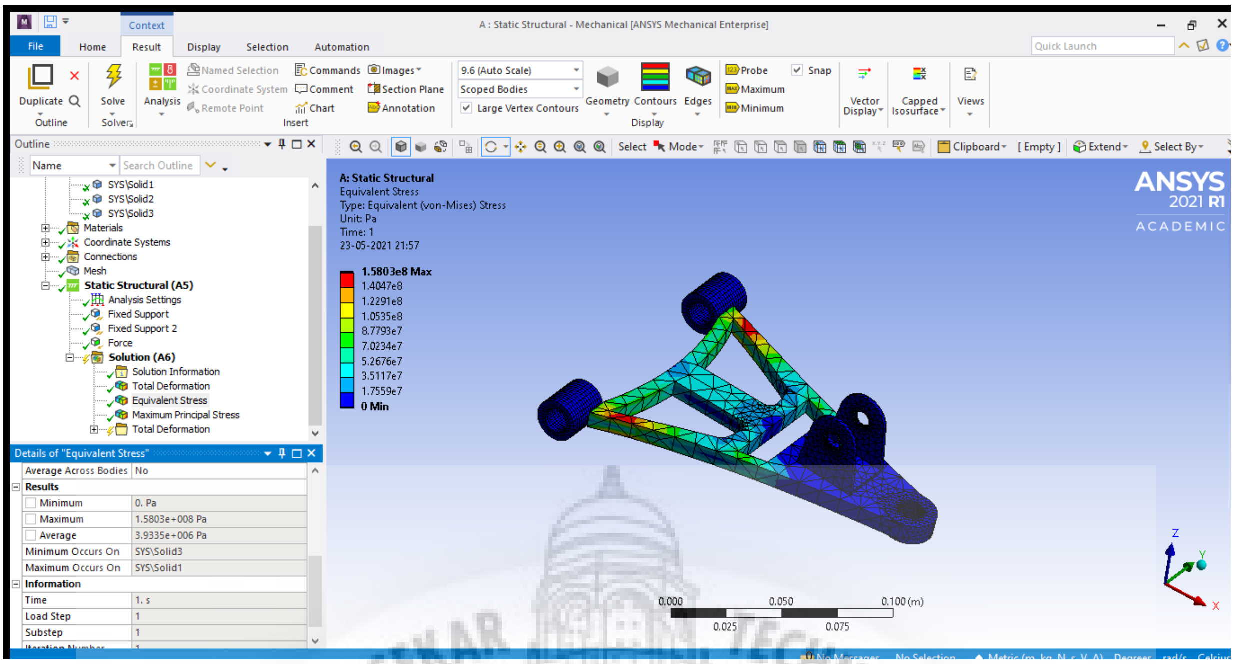


Fig 1.5.5

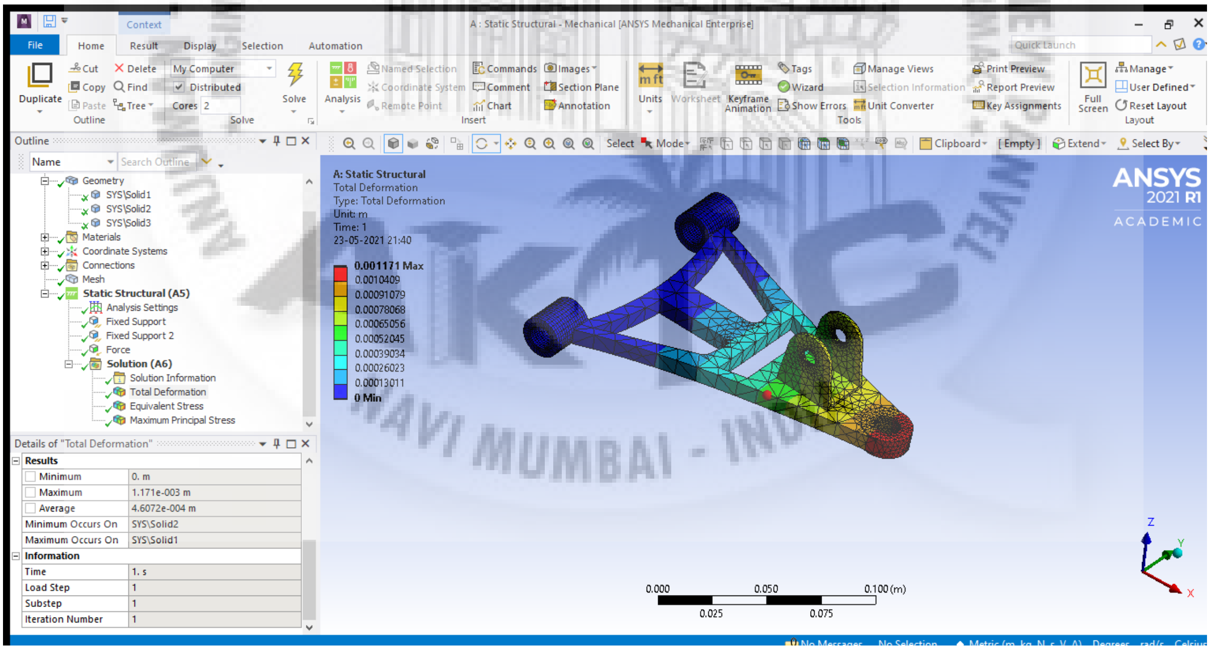


Fig 1.5.6

c. Trailing Arm:

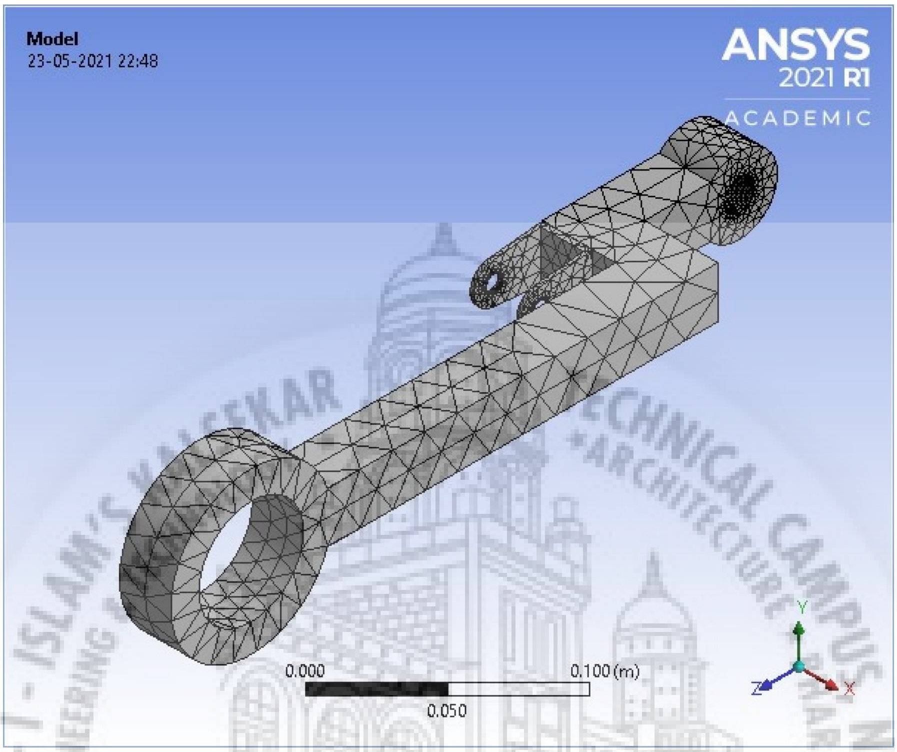
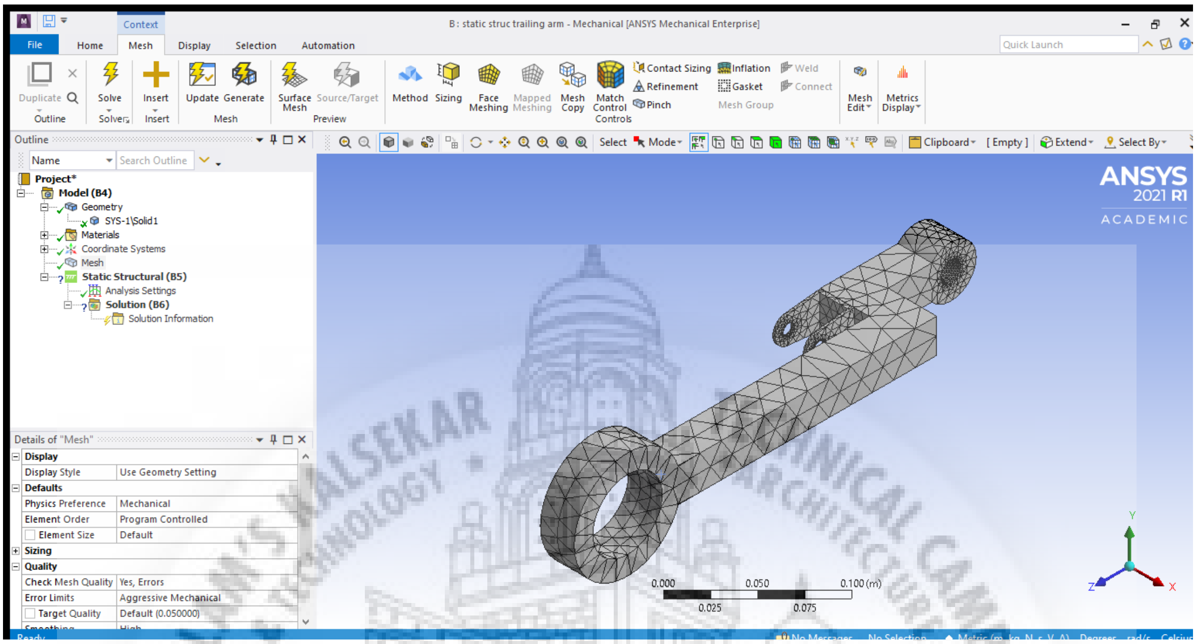


Fig 6.1.1: Trailing arm

Units:

TABLE 1

Unit System	Metric (m, kg, N, s, V, A) Degrees rad/s Celsius
Angle	Degrees
Rotational Velocity	rad/s
Temperature	Celsius



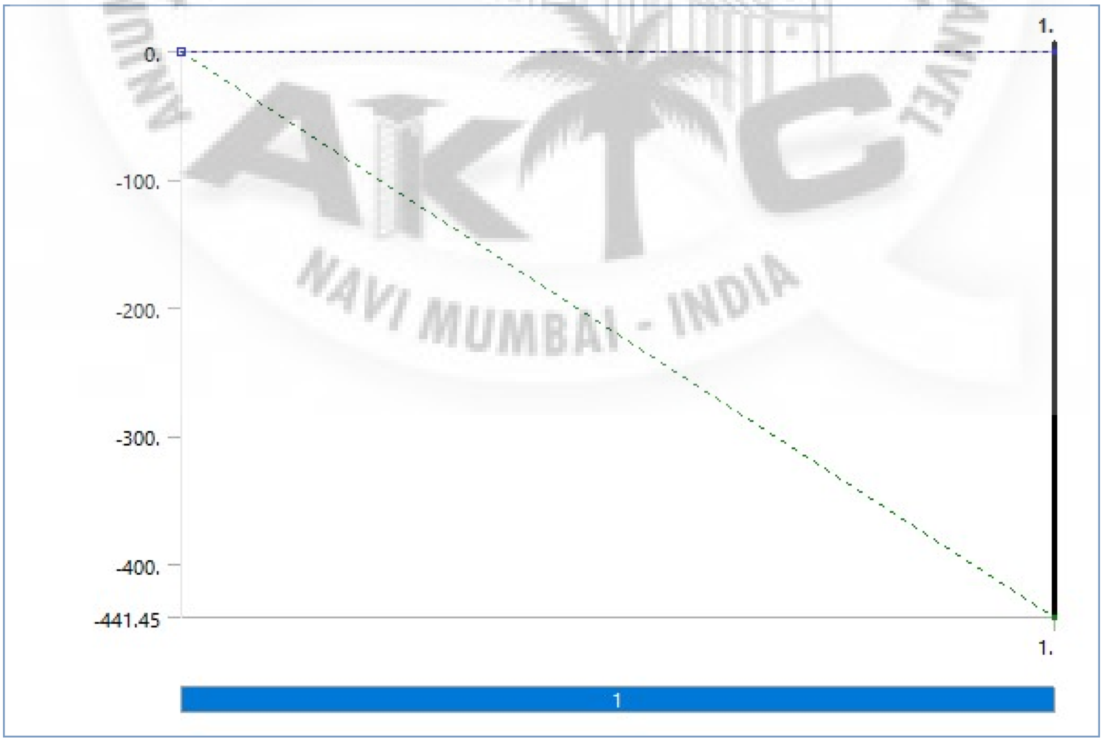


Fig 6.1.2
Model (B4) > Static Structural (B5) > Force

TABLE 12
Model (B4) > Static Structural (B5) > Solution (B6) > Results

Object Name	*Total Deformation*	*Equivalent Stress*	*Maximum Principal Stress*
State	Solved		
Scope			
Scoping Method	Geometry Selection		
Geometry	All Bodies		
Definition			
Type	Total Deformation	Equivalent (von-Mises) Stress	Maximum Principal Stress
By	Time		
Display Time	Last		
Calculate Time History	Yes		
Identifier			
Suppressed	No		
Results			
Minimum	0. m	35.545 Pa	-8.7436e+006 Pa
Maximum	1.7624e-004 m	1.3659e+008 Pa	1.1098e+008 Pa
Average	1.3502e-004 m	2.7018e+006 Pa	1.5204e+006 Pa
Minimum Occurs On	SYS-1\Solid1		
Maximum Occurs On	SYS-1\Solid1		
Information			
Time	1. s		
Load Step	1		
Sub step	1		
Iteration Number	1		
Integration Point Results			
Display Option		Averaged	
Average Across Bodies		No	

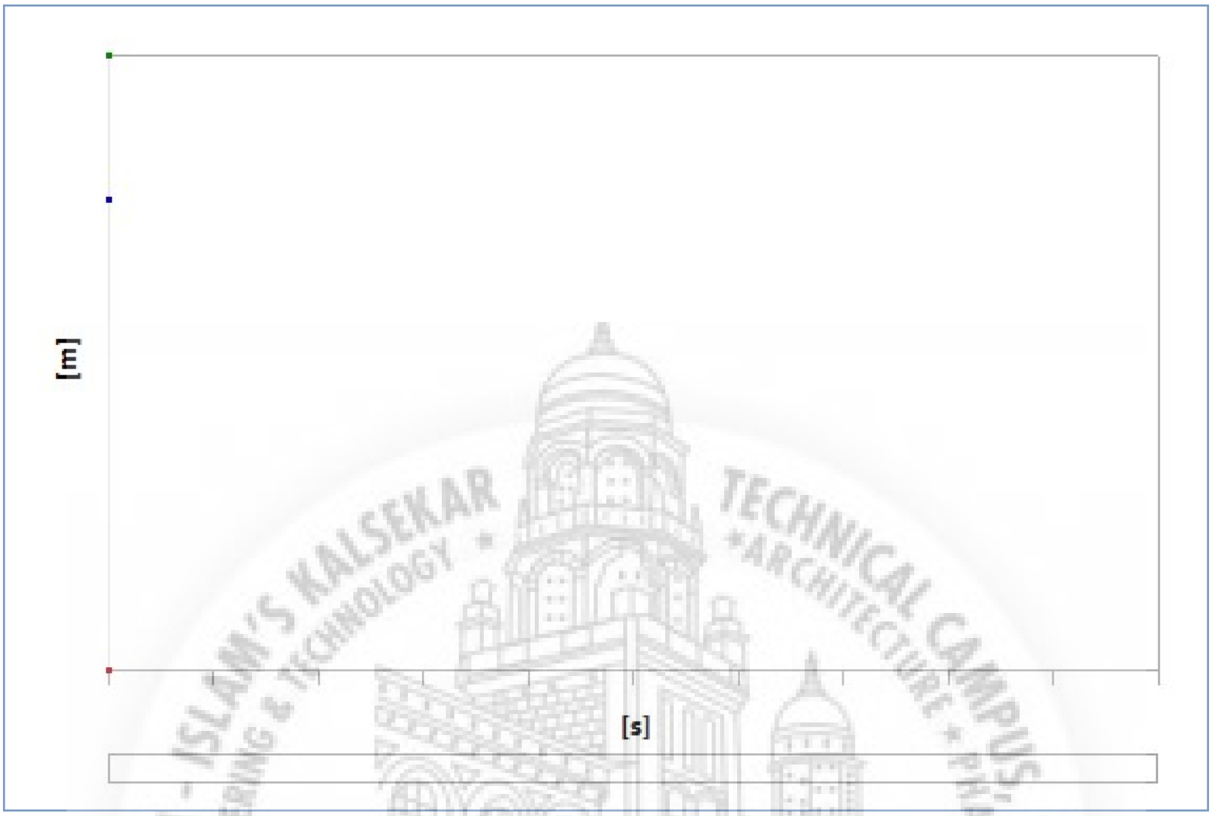


Fig 6.1.3:
Model (B4) > Static Structural (B5) > Solution (B6) > Total Deformation

TABLE 13
Model (B4) > Static Structural (B5) > Solution (B6) > Total Deformation

Time [s]	Minimum [m]	Maximum [m]	Average [m]
1.	0.	1.7624e-004	1.3502e-004

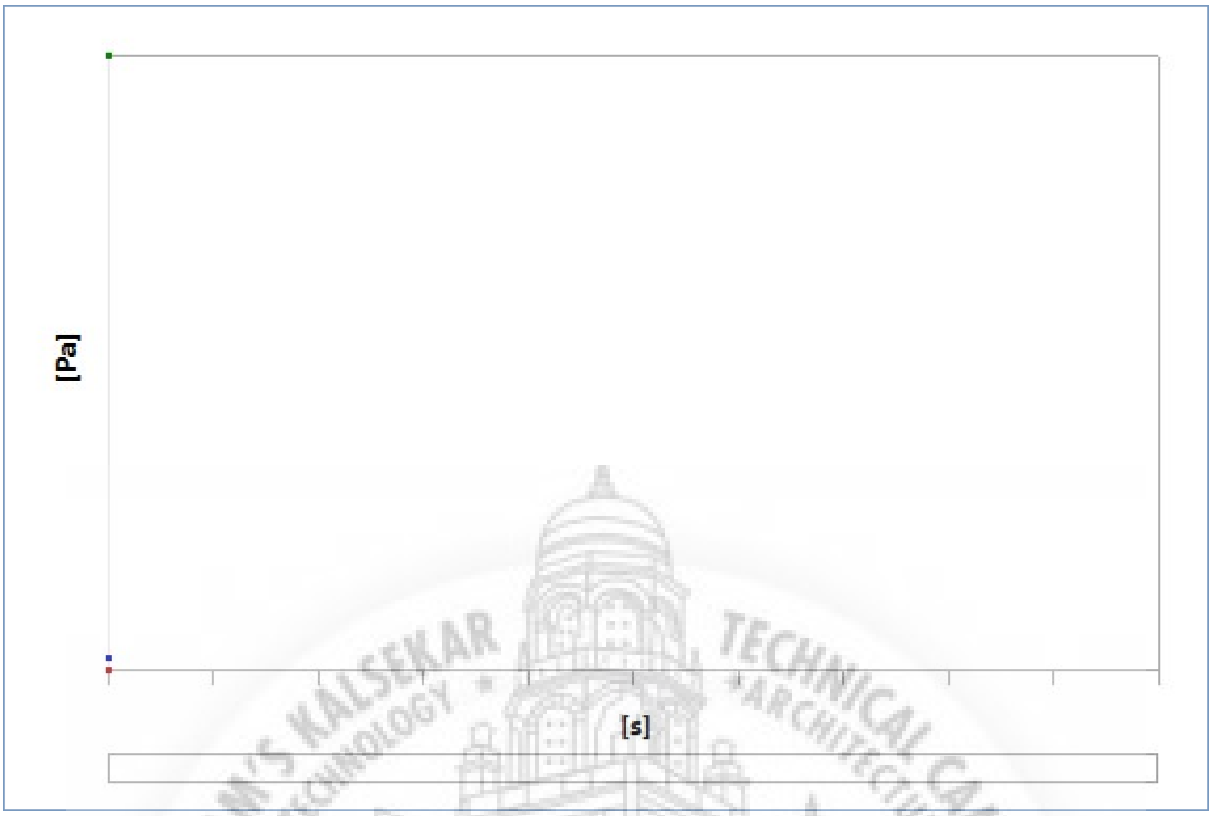


Fig 6.1.4:
Model (B4) > Static Structural (B5) > Solution (B6) > Equivalent Stress

TABLE 14
Model (B4) > Static Structural (B5) > Solution (B6) > Equivalent Stress

Time [s]	Minimum [Pa]	Maximum [Pa]	Average [Pa]
1.	35.545	1.3659e+008	2.7018e+006

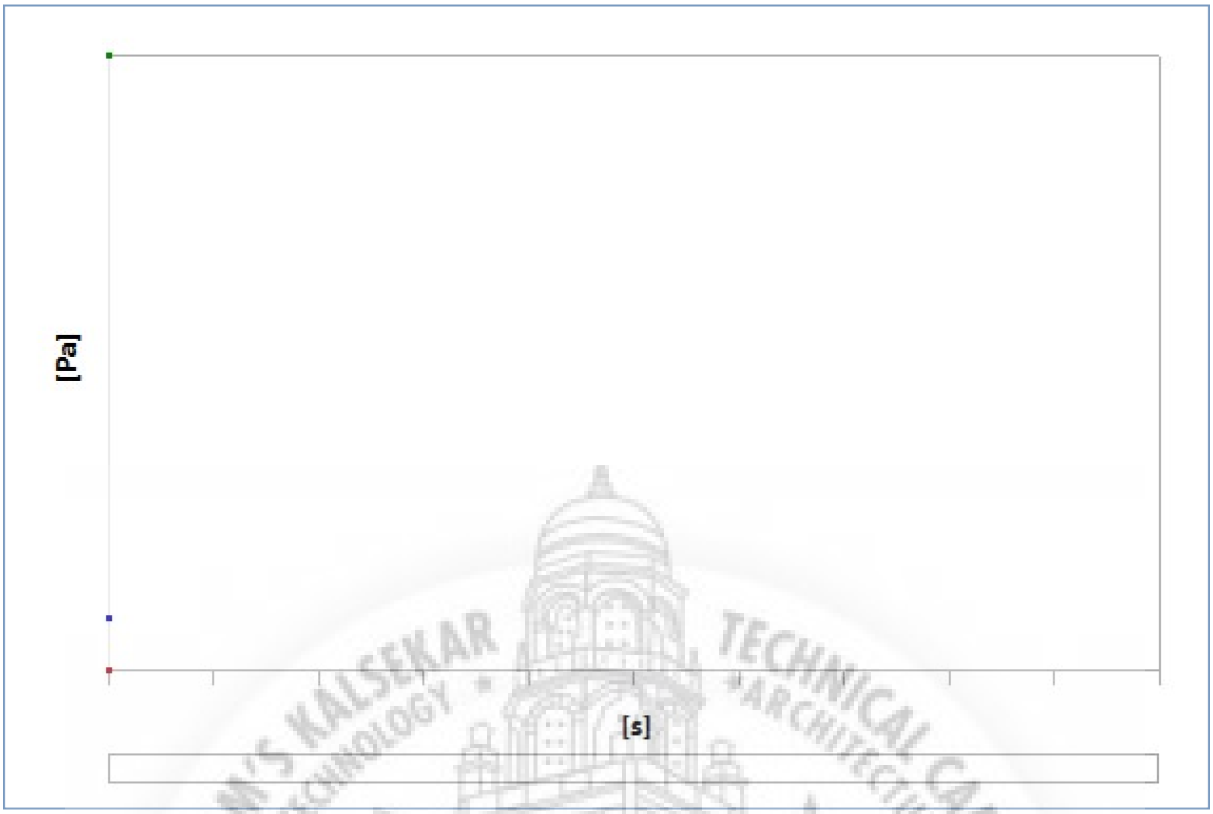


Fig 6.1.5
Model (B4) > Static Structural (B5) > Solution (B6) > Maximum Principal Stress

TABLE 15
Model (B4) > Static Structural (B5) > Solution (B6) > Maximum Principal Stress

Time [s]	Minimum [Pa]	Maximum [Pa]	Average [Pa]
1.	-8.7436e+006	1.1098e+008	1.5204e+006

Material Data
AISI 4130

TABLE 16
AISI 4130 > Constants

Density	7850 kg m^-3
Coefficient of Thermal Expansion	1.2e-005 C^-1
Specific Heat	434 J kg^-1 C^-1
Thermal Conductivity	60.5 W m^-1 C^-1
Resistivity	1.7e-007-ohm m

TABLE 17 AISI 4130 > Color

Red	Green	Blue
132	139	179

TABLE 18
AISI 4130 > Compressive Ultimate Strength

Compressive Ultimate Strength Pa
0

TABLE 19
AISI 4130 > Compressive Yield Strength

Compressive Yield Strength Pa
2.5e+008

TABLE 20
AISI 4130 > Tensile Yield Strength

Tensile Yield Strength Pa
4.6e+008

TABLE 21
AISI 4130 > Tensile Ultimate Strength

Tensile Ultimate Strength Pa
5.6e+008

TABLE 22
AISI 4130 > Isotropic Secant Coefficient of Thermal Expansion

Zero-Thermal-Strain Reference Temperature C
22

TABLE 23
AISI 4130 > S-N Curve

Alternating Stress Pa	Cycles	Mean Stress Pa
3.999e+009	10	0
2.827e+009	20	0
1.896e+009	50	0
1.413e+009	100	0
1.069e+009	200	0
4.41e+008	2000	0
2.62e+008	10000	0
2.14e+008	20000	0
1.38e+008	1.e+005	0
1.14e+008	2.e+005	0
8.62e+007	1.e+006	0

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TABLE 24
AISI 4130 > Strain-Life Parameters

Strength Coefficient Pa	Strength Exponent	Ductility Coefficient	Ductility Exponent	Cyclic Strength Coefficient Pa	Cyclic Strain Hardening Exponent
9.2e+008	-0.106	0.213	-0.47	1.e+009	0.2

TABLE 25
AISI 4130 > Isotropic Elasticity

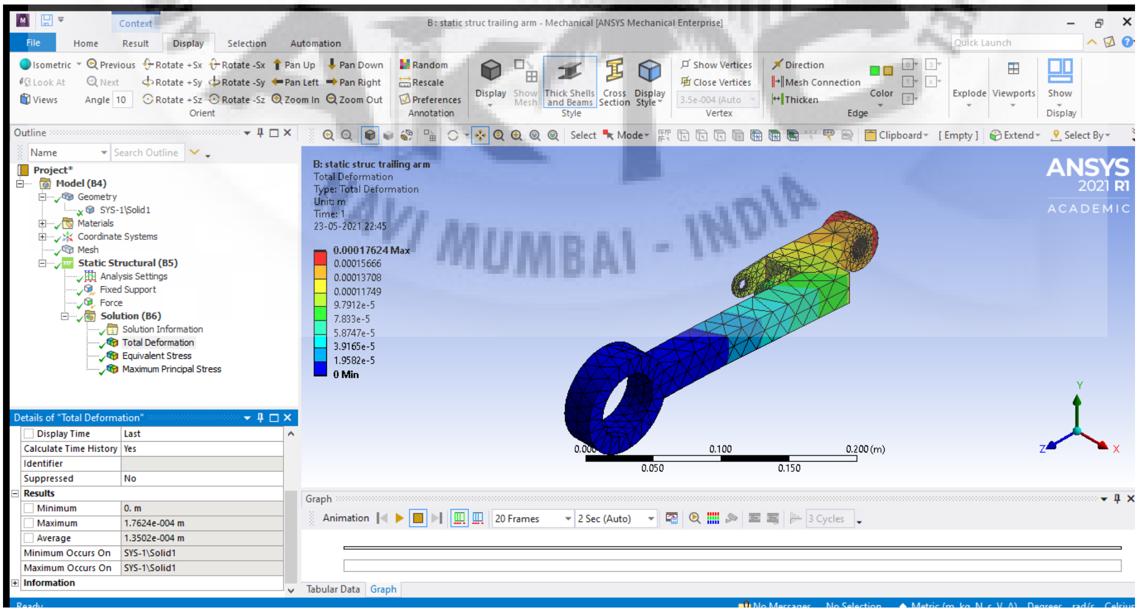
Young's Modulus Pa	Poisson's Ratio	Bulk Modulus Pa	Shear Modulus Pa	Temperature C
2.016e+011	0.26	1.4e+011	8.e+010	

TABLE 26
AISI 4130 > Isotropic Relative Permeability

Relative Permeability
10000

TABLE 27
AISI 4130 > Melting Temperature

Melting Temperature C
1432



CHAPTER 5

Steering System

5.1 Ackermann-type steering Mechanism

The generally used steering mechanisms for four-wheel vehicles are four-bar linkages which are often called Ackermann-type steering mechanisms. The input motion from the driver at the steering wheelies transmitted via a steering box and the steering control linkage to one of the steering knuckles and then transmitted to the other one through the Ackermann Steering linkage. The main kinematic requirement of the steering linkage of a vehicle is to provide the steer-able wheels a correlated pivot such that their axes intersect at a point on the rear wheel axis.

The objective for the synthesis of steering mechanism is to minimize the difference between the centers over the full range of steering angle inputs while fitting into a reasonable space. To obtain the target, several con-flicking requirements should be simultaneously considered.

A possible formulation of the optimization-based synthesis problem is to search for the values of Parameters. In addition, differential mechanism coupled to a higher pair, resolves the single input coming from the steering wheel into two outputs satisfying the condition of correct steering.

5.2 Standard Tie rod:

In the previous design there was not a standard tie rod in the steering mechanism that led to improper composition and discomfort to the driver who is a handicap person hence, we replaced it with a standard tie rod as shown below.

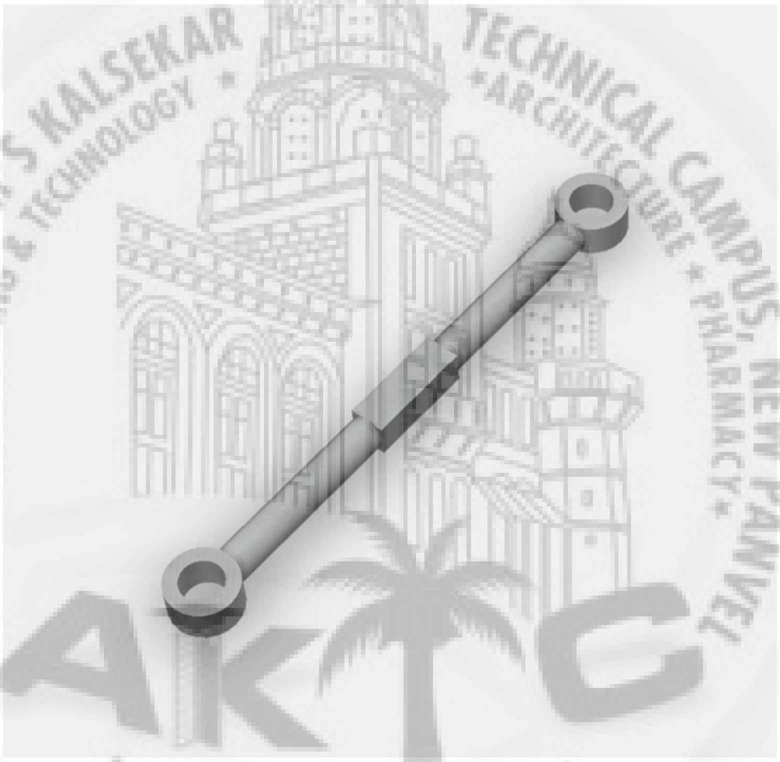


Fig: 5.2.1 Tie rod

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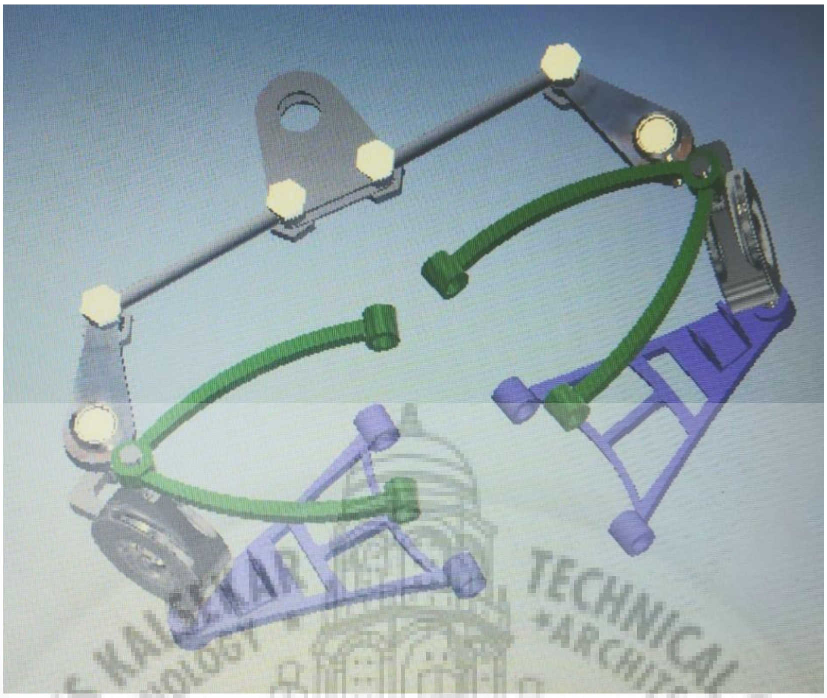

Fig: 5.2.2

Fig: 5.2.3

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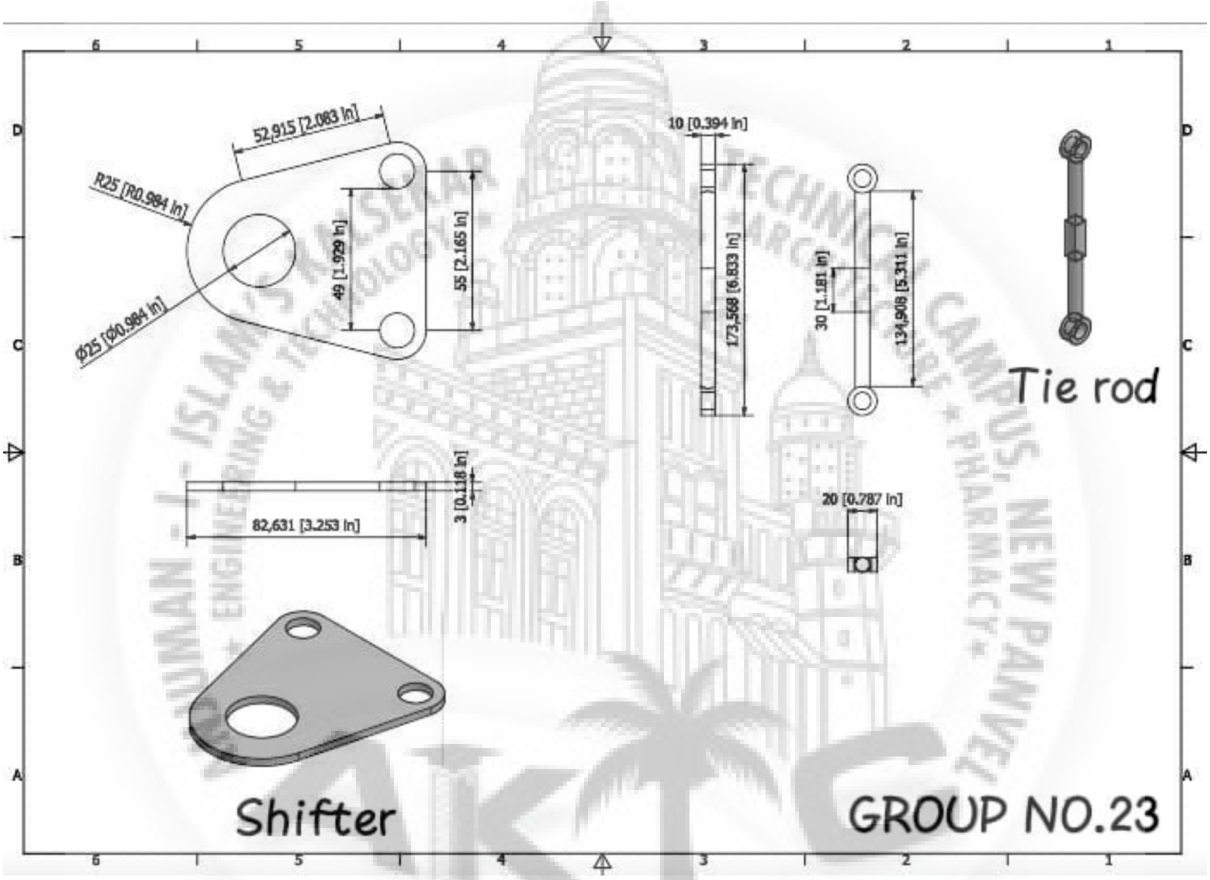
52,915 [2,083 In]
R25 [R0,984 In]
Ø25 [Ø0,984 In]
49 [1,929 In]
55 [2,165 In]
10 [0,394 In]
173,568 [6,833 In]
30 [1,181 In]
134,908 [5,311 In]
3 [0,118 In]
82,631 [3,253 In]
20 [0,787 In]
Tie rod
Shifter
GROUP NO.23

Fig: 5.2.4

5.1.1 Advantages:

The intention of Ackermann geometry is to avoid the need for tires to slip sideways when following the path around a curve. The geometrical solution to this is for all wheels to have their axles arranged as radii of circles with a common Centre point. As the rear wheels are fixed, this center point must be on a line extended from the rear axle. Intersecting the axes of the front wheels on this line as well requires that the inside front wheel is turned, when steering, through a greater angle than the outside wheel.

Rather than the preceding "turntable" steering, where both front wheels turned around a common pivot, each wheel gained its own pivot, close to its own hub. While more complex, this arrangement enhances controllability by avoiding large inputs from road surface variations being applied to the end of a long lever arm, as well as greatly reducing the fore-and-aft travel of the steered wheels. A linkage between these hubs pivots the two wheels together, and by careful arrangement of the linkage dimensions the Ackermann geometry could be approximated.

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5.1.2 Angle Calculation:

We take the following aspects for steering design by keeping mind the Indian road conditions, like bums in road, sharp and blind turns, and also the Indian road traffic situations.

Assumptions:

1. Inner Wheel Turning radius: 40 Deg.

Empirical Data:

1. Ackerman arm length: 2.814 Inch
2. Track rod length: 14.257 inch
3. Track rod axis distance from front axle: 5.123 Inch
4. TW = 24.14 inch.
5. WB = 40 inch.

Ackerman Geometry Calculations:

Extra Length (e): 47.67 inch

Inside turning radius (Ri): 62.22 inch

Outside turning radius (Ro): 82.19 inch

Outside wheel turning angle (ϕ): 29.12 Deg.

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Ackerman arm calculation:

- Z = Length of track rod.
- Y = Length of tie rod.
- X = Length of Ackerman arm.
- D = Distance between Z & front axle.

β= 0.5*TW / WB

= **16.79 Deg.**

Steering Effort Calculations:

- Consider the total weight of the vehicle to be **250 kg**
- Consider the 60% of the weight on rear & 40% on front.

Therefore, weight in front = 0.40*250

= **100 kg**

On one of the two front wheels = 100/2

= **50 kg.**

- The force acting on one of the front wheels due to the weight of vehicle (W):

W = 50*9.81

= **490.5 N**

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- Resisting force from the wheel (Rf):

$$
\begin{aligned}
Rf &= \mu * W \\
&= 1.4*490.5 \\
&= \mathbf{686.7\ N}
\end{aligned}
$$

- Resisting torque on the wheel,

$$
\begin{aligned}
Tr &= Rf*\text{Scrub radius (Sr)} \\
&= 686.7*25.4 \\
&= \mathbf{17442.18\ N.mm}
\end{aligned}
$$

- Minimum steering effort:

$$
\begin{aligned}
Rf*Sr &= P*i \\
686.7*25.4 &= P * 119.538 \\
\mathbf{P} &= \mathbf{145.91\ N}
\end{aligned}
$$

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5.1.3 Steering Drawing:

To the scale drawing as per design requirements

Figure 5.1.3 Steering drawing with 1:2 scale (Left turn)

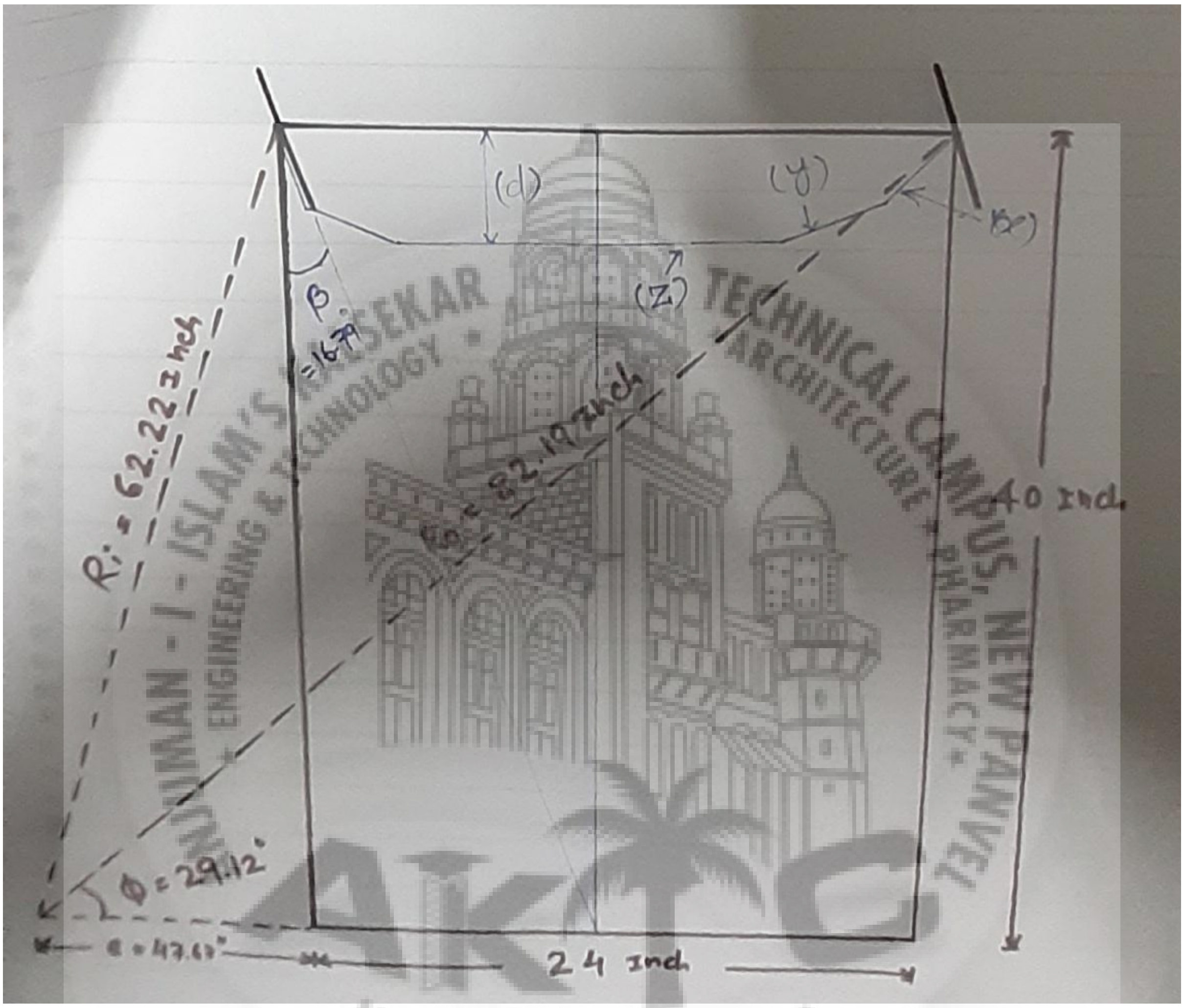

Fig: 5.1.1

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FINAL MODEL

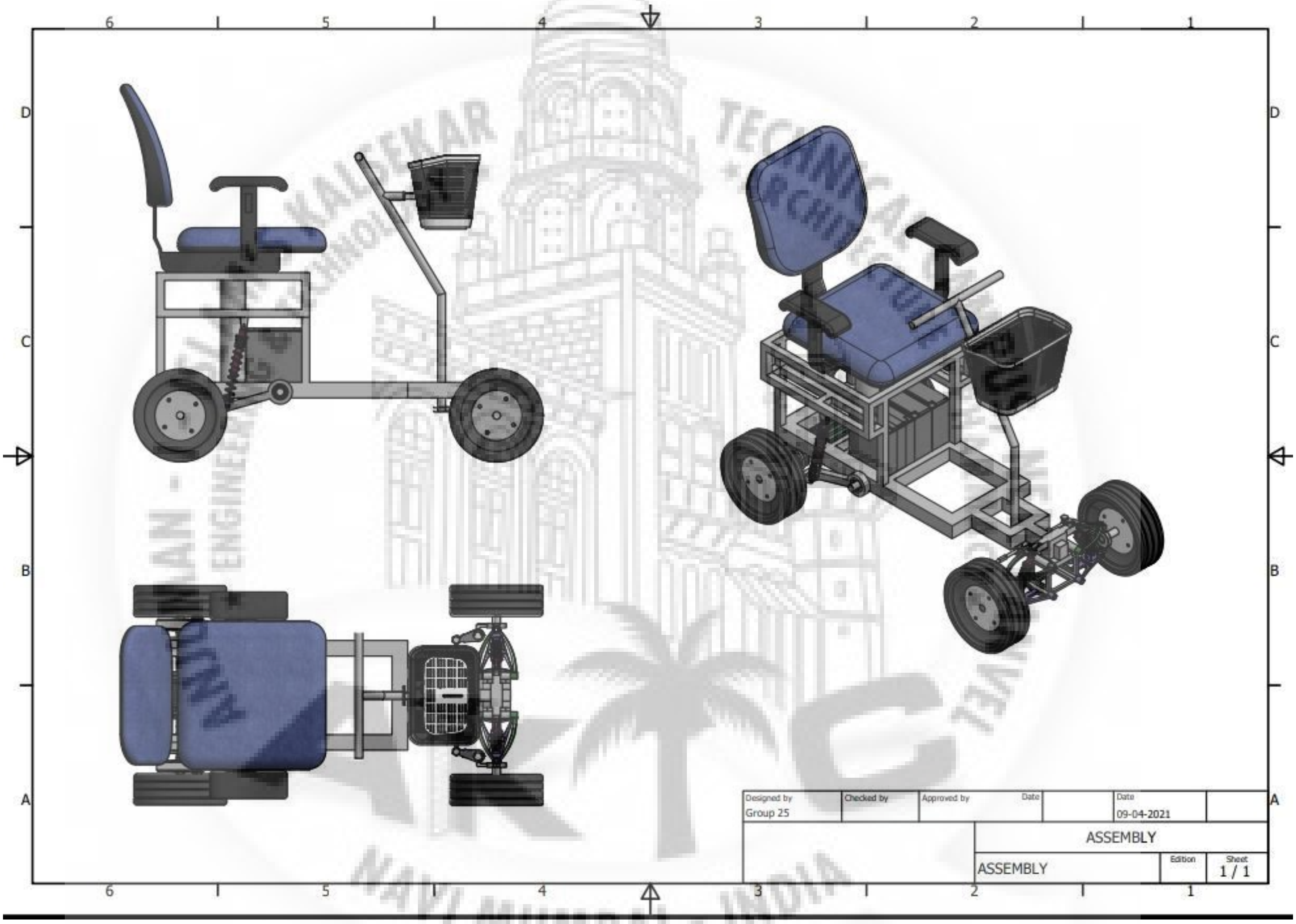

Fig: 6.1

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Chapter 6

Future Scope

1. The scooter can be made a two-seater.
2. Safety devices such as air bags, GPS etc. can also be employed.
3. Facility to send emergency messages.
4. A remote controller can be used to control its functions.

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   Volume 10, Issue 2 (February 2014), PP.22-28

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