

DESIGN & FABRICATION OF A RETRACTABLE COVER FOR DIRT PROOFING OF AUTOMOBILES

Thesis submitted for the undergraduate degree in Mechanical Engineering
at the
University of Central Punjab



PROJECT MEMBERS:

AMANULLAH: L1F19BSME0028
HAMMAD AHMAD: L1F19BSME0033
M. ABUBAKAR SHAKIR: L1F19BSME0038

PROJECT ADVISOR(s):

Dr. MUHAMMAD KASHIF
Mr. AHMED ZOHAIB ZAIDI

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Department of Mechanical Engineering,
University of Central Punjab, Lahore Pakistan

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Internal Examiner:

External Examiners:

Name and Title:

Affiliation:

Signature:

Name and Title:

Affiliation:

Signature:

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ABSTRACT

Early in the 20th century, cars were readily accessible. Thanks to modern technology, every feature of a car has been created with the user's comfort in mind. To protect them from UV rays and rain, cars are frequently kept in garages or in shaded areas, although a vehicle cover can be used. The use of a car cover will keep our vehicles considerably cleaner and save us a lot of time and money on frequent car washes. A car cover is an essential tool for protecting our vehicles. Therefore, a simple retractable car cover system must be created for quick and effective vehicle covering. We try making prototype of simple, inexpensive retractable system that covers the entire vehicle to protect it from dirt, mud, sunlight, rain, and scratches. In comparison to traditional covers, it needs to be simple to use and quick to cover. If the user desires, this device can also be automated. Even in the worst-case scenario, if a car cover deploys properly, it will safeguard the expensive vehicles. There should be installed automated sensors that's detect the environment Installed sensors and controls that detect environmental conditions such as rain, snow, or intense sunlight. Based on the detected conditions, these sensors would automatically deploy or retract the cover.

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LIST OF ABBREVIATIONS AND ACRONYMS

RCC	Retractable Car cover
CAD	Computer-Aided Design
CEP	Complex Engineering Problem
SDGs	Sustainable Development Goals
UN	United Nations
RSSMs	Rectilinear Scissor Structural Mechanisms
SS	Stainless Steel

CHAPTER ONE: INTRODUCTION

This chapter highlighted the objective and aim of retractable car covers. The main aim and objective of a retractable car cover is to shield a vehicle from external elements like sunshine, dust, and moisture. This can keep the car's inside dry and clean while also maintaining the car's appearance and value. Since the cover can be simply rolled up and stored when not in use, its retractable function makes it more practical to use than a conventional car covers. It includes the working, advantages, application and how it differentiates from car shelter and car covers.

1.1 Project Background

In early 20th century, car has become widely available. Today's technology has advanced, and every aspect of an automobile has been designed with the user's comfort in mind. Cars are often kept in a garage or in a shaded location to protect them from UV rays and rain, but a vehicle cover can be utilized. A Car Cover is an important tool for protection of our cars, using a car cover will keep our Vehicle much cleaner and save a lot of time and money on Frequent car washings. Our car's biggest enemies are Sun, Tree sap, Dust Particles, Animal Deposits, some chemical fallouts which are surrounded by sea, that possesses a humid climate thus due to the humidity the life span of car material start decreasing. With so many other uncovered cars, our vehicle is much less likely to be meddled with than another vehicle without car cover. As we all know the fact that human beings try to do the tasks which are easier and less time consuming. The car covering and removing is one of the time consuming and difficult tasks as it involves proper removal and application of cover, Management of cover is one of the most difficult tasks in the entire process. Covering the car with a car cover requires manual work and is a difficult task. Also, there is contact area between car and car cover which can have produced starches on the body of the car. If we used the cars without car covers, which may can produced dust, dirt, and starches on the body of the car. This will impact on water. According to the survey, people washed their cars almost 13 times a year. They used a lot of water for washing their cars. There is need to design such a mechanism that is capable of protecting the cars against various conditions. This mechanism will open and close by just pushing the button which save time and required less human expertise. It will protect cars against dust, dirt, mud and starches.

1.2 About Car Cover

Since automobile covers are both protective and potentially destructive, they have both numerous advantages and some disadvantages. It's possible that an improperly fitted car cover poses more of a risk than none at all. If the car cover is simply too flimsy, wind could push it against the paint and seriously harm it. To ensure the greatest fit, order a cover that is specifically made for the year and manufacturer of your automobile. Although the "one size fits all" designs are less expensive, they do not offer the required tight fit. If the car isn't clean, dirt may get stuck between the duvet and the paint and result in scratches when the cover is put on or taken off, or when the wind blows the cover around. Use a properly fitted vehicle cover

on a clean car to avoid these issues. Some car covers have a bottom locking mechanism that enables a cable to easily transport the duvet's rock bottom. This could help prevent cover movement and peeking burglars.

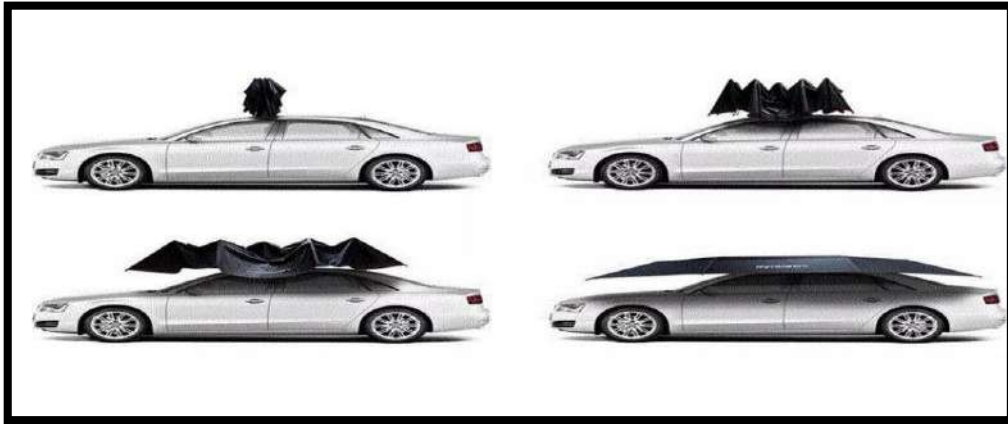


Figure 1.1: Automatic car umbrella type [2]

1.3 Car shelter

A large sheet of protective fabric material shaped like a car serves as a car shelter. A car shelter is used to safeguard a vehicle when it is not in use for an extended period of time. A source of pride is owning and keeping a brand-new car. Our automobile can be shielded from UV rays and rain by using a vehicle cover or parked in a shady place. There may be shaded places inside of a tent or under a roof. Each of these has a unique set of advantages and disadvantages. With the help of a car shelter, we may shield your parked vehicle from the damaging effects of acid rain, UV rays, bird droppings, sun fading, windborne particles, animal claws, and even the nosy eyes of thieves. A sturdy cover in garage serves as a deterrent to pests carried by foot and debris carried by the wind. The cost of the vehicle cover may be low, but installing it on the car and taking it off and folding it both need time and labor. However, when it rains, the worker gets wet when covering due of the wind and the process takes longer. The tent or roof, on the other hand, may be bought and set up; a car can be parked underneath it, but it cannot be carried. Nowadays, because to advancements in technology, there are many different types of vehicles shelters available. Here are a few of the newest designs for auto shelters.



Figure 1.2: Car Shelter [2]

1.4 Car cover material

There are three main types of cars covers available on the market, each with its own set of benefits and drawbacks.

- a. Water proof
- b. Dust resistant
- c. Air resistant

The main advantage of having a water-resistant vehicle cover is that it shields the automobile from the elements. These rain-repellent automobile covers are frequently created from plastic-coated or film-coated cloth. But using this kind of canopy can cause moisture to build up between the car and your car cover. The accumulated moisture could lead to issues that are more severe than if you had simply left the car open. When parking your automobile in a garage for the winter, you should use this kind of car cover. A flannel fabric cover placed against the surface is one of the best solutions. The second category consists of water-resistant car covers, sometimes referred to as breathable car covers, which are available in a bewildering assortment of materials, designs, and weights. Most of the rain will be kept out of the vehicle by these sorts of coverings, which also let air flow and lessen moisture. These car covers shouldn't be left outside for a lengthy amount of time because they are not waterproof. The majority of consumers utilize these types of protection for interior usage, and these materials are mild on paint, whereas polyester may damage the paint.

1.5 Problem Statement

According to the information gathered on car shelters, problems linked with them have been identified. In certain cases, the system (vehicle covering system) is portable; nevertheless, this method needs human work and expertise to cover the automobile, unlike in automatic car umbrella types, the entire car is not covered. At certain cases, the technology is not portable, therefore the automobile must be parked just in that location. It's also tough to conceal the automobile. Sometimes car cover can be used for this purpose. However, take out the car cover from the trunk and deploy that all over the car is a cumbersome job. Furthermore, it is very hard to deploy the cover when there are extreme weather conditions like rain etc. Therefore, a simple retractable car cover mechanism needs to be designed for easy and efficient covering of automobiles.

1.6 Societal Need

Cars were increasingly accessible in the early twentieth century, replacing animal-drawn carriages and carts. By 2050, there will be about 3 billion light-duty vehicles on the road worldwide, up from 1 billion now. A car cover that does not fit properly may be more harmful than no cover at all. If the car cover is just too loose, that will have produced dust, mud, and scratches on the car. Therefore, car cleaning mainly depends on water, Half of the world's population could be living in areas facing water scarcity in coming years. To avoid these

difficulties, a retractable car cover can shelter the car manually which save time, money and economize water.

1.7 Solution Proposed

We propose to design and fabricate a simple and low-cost retractable mechanism that covers the entire car to protect it from dust, dirt, mud, sunlight, rain and scratches. It should be easy to operate and should take less time to cover as compared to conventional covers. This mechanism can also be motorized if required by end user. If a car cover deploys automatically, it will safeguard the expensive vehicles even in the worst-case scenario. The present application's goal is to offer a car cover that automatically comes out of a car's trunk, deploys, and returns to the trunk with the touch of a key.



Figure 1.3: Retractable car cover [2]

1.8 Advantages of a Retractable Covers

There are some advantages of retractable car cover which protect a car from getting dirty and wet during rainy and snowy seasons.

- Better Open Car Parking Solution.
- Less Energy Consumed by the system hence reduces cost
- Better Protection from Dust, Scratches, Color Fading, Rusting etc.
- Overall cost of this system is low.
- As it is Automated it reduces the manual efforts of applying and removing cover hence saves time.
- Can cover entire area of the Car

1.9 Applications of a Retractable Covers

The retractable frame is not only used for car covers, but also in various other applications, such as:

- Retractable awnings: Retractable frames are used to support and roll up awnings, which are used to provide shade and shelter from the sun and rain.
- Retractable roofs: Retractable frames are used to support and roll up roofs, which are used to cover open-air spaces such as patios, decks, and swimming pools.
- Retractable enclosures: Retractable frames are used to support and roll up enclosures, which are used to enclose open-air spaces such as patios, decks, and swimming pools.
- Retractable walls: Retractable frames are used to support and roll up walls, which are used to create or enclose indoor or outdoor spaces.
- Retractable screens: Retractable frames are used to support and roll up screens, which are used to provide privacy, shade, or insect protection.
- Retractable banners: Retractable frames are used to support and roll up banners, which are used for advertising, branding, or decoration.

1.10 Scope of the Project

The scope of the project will define how we achieve our projects while performing steps. These steps are:

- Gather information: Information is gathered from many sources, including the internet and journals. These details are significant since they will be needed later.
- Design and Modeling: we will be modeling on zero/ solid work
- Analysis of mechanisms: define the mechanism like which mechanism on working it
- Fabrication: Here we will survey the market and purchase all the required material and items. This phase will also begin the assembling of the project.
- Testing: here will perform testing on adjustable dimension for hatchback, SUV & Sedan
- Analysis: Critical part analysis is done using ansys software.

1.11 Mapping with Complex Engineering Problem Attributes

This table shows the list of CEP attributes which lines up with our project.

Table 1.1 CEP Attributes

CEP Attributes		
WP1	Depth of knowledge	WK3 - Engineering Fundamentals WK4 - Engineering Specialist Knowledge WK5 - Engineering Design WK6 - Engineering Practice (Modern tools)
WP3	Depth of analysis required	Overall Sizing Stress analysis Material Cost
EP2	Judgement (Professional Competency)	Material selection, Pipe size selection and mechanism

1.12 Mapping with UN SDGs

1.12.1 Industry, Innovation and Infrastructure

Basically, our project is innovation base because it is not available in the market and important for the world. And then it linked with the industry when we go for a mass production for this type of car cover.



Figure 1. 4: UNSDG (9) [19]

1.12.2 Responsible Consumption & Production

According to the survey daily 8 million cars are washed in the America and averagely about 13 time a car is washed in a year. And about 100 liters is used for simple car washed. And after using car cover, car washed is decrease because it protects it from dirt and dust.

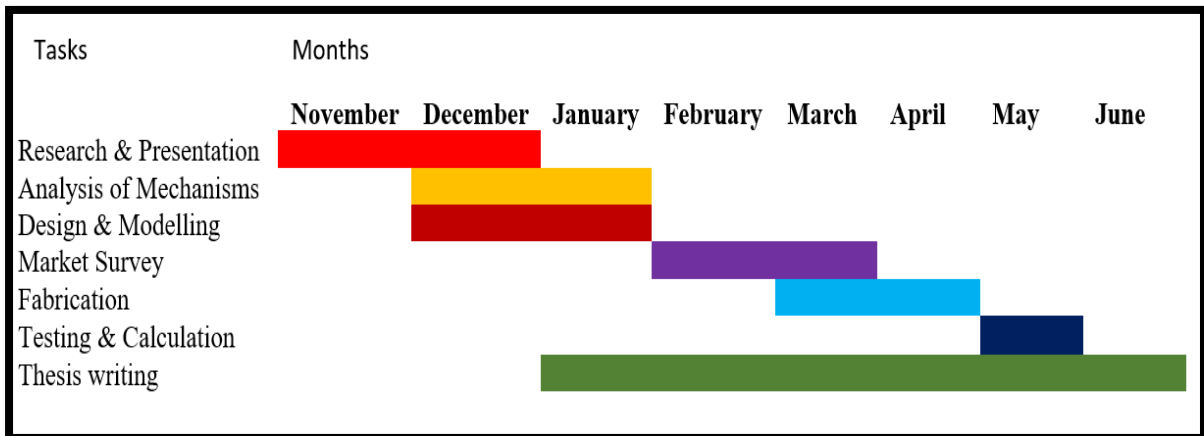


Figure 1.5: UNSDG (12) [20]

1.13 Gantt Chart

The Gant Chart shows the visual representation of our month wise activity of the project. This is our gantt chart in which our monthly plan is display we do research, design and modeling, analysis of mechanism, market survey, fabrication, and testing.

Table 1.2 Gantt Chart



CHAPTER TWO: LITERATURE REVIEW

In literature, we researched out multiple articles that's relates car cover mechanism. A literature review is an overview of the previously published works on a topic. Here are literature reviews in which different research published that's collate objective of project. The many designs, components, and features of retractable automobile covers would probably be covered in a review of the relevant literature. It would probably look at the advantages of utilizing a retractable car cover, like ease and vehicle protection. It would also look at retractable car covers' shortcomings or restrictions, such as their price or durability. Retractable car covers may be compared to other vehicle cover kinds, such as conventional car covers or carport buildings, in the evaluation.

2.1 Literature Review

There are numerous items created specifically to provide rain protection for vehicles. For covering the car, the following inventions have already been made.

A vehicle cover that automatically extends over the vehicle using a guide element and retracts into a storage position is described here, building on the first innovation US4432581A.

Another remotely controlled power-assisted vehicle cover described in US4848823A has cylindrical cover containment tubes and a wireless remote transmitter control for operating functions. It is attached to a take-up winding and unwinding mechanism that is attached to the trailing end of the cover.

An automatic car cover that uses electric motors to open and close the trunk lid is described in US20090140541A1. One cover runner, one holster, one casing for the holster, one guide, one cover sheet, and one cover sheet un-folder make up the system. By simply pressing a button, the entire automatic system turns on.

In addition to this, let's look at an example of a van camper, which comes with several built-in characteristics, such as the ability to change the interior and exterior according on the situation. However, the issue is that once it is released, physical labor is required.

A square box of cover that will automatically cover the entire car in just 15 seconds is one of the newest technologies to enter the market.

Only the remote is used to control the box's spin.

- Here are some others mechanisms that's are used for covering the car covers:

2.2 Design and Finite Element Analysis of Automatic Car Cover

In early 20th century, car has become widely available. However, it is a hard job to remove the car cover from the trunk and spread it out all over the vehicle. Furthermore, when there are severe weather conditions, such as rain, etc., it is very difficult to deploy the cover. It's possible that an improperly fitted car cover provides more of a risk than none at all. The automobile will have dust, mud, and scratches if the car cover is simply too loose. Therefore, a straightforward retractable car cover system must be created for quick and effective vehicle covering. In comparison to traditional covers, it needs to be simple to use and quick to cover. If the user desires, this device can also be mechanized. This mechanism can also be motorized if required by end user. If a car cover deploys automatically, it will safeguard the expensive vehicles even in the worst-case scenario [2].

2.3 Designing an Auto Retractable from Heat

Auto retractable roof is a new alternatives car covers that can have used to cover the car from sunshade and corrosion effect. After parking under direct sunlight with a high temperature of around 36.5°C, the retractable roof is utilized to protect the body of the automobile from corrosion and to protect the occupants from the heat. When droplets hit the windscreen during a heavy downpour, visibility might also be lowered. Even the greatest automotive air conditioners can take 10 to 20 minutes to cool the area around the driver to a comfortable temperature while they are seated in the vehicle. In order to provide comfort for vehicle occupants and lower interior temperature, a new auto retractable roof needs to be designed. To overcome this problem, a device will be designed & analyzed which can reduce the heat imposed by the hot sun. It will cover up the roof of car [3].

2.4 Auto Smart Car Cover

Our car's biggest enemies are Sun, Tree sap, Dust Particles, Animal Deposits, some chemical fallouts and in some cities especially Mumbai which is surrounded by sea, which possesses a humid climate thus due to the humidity the life span of car material start decreasing. Folding and unfolding then keeping the cover back is a hectic work to do, hence to avoid all the hectic work here we have invented an Automated Smart Car Cover to reduce our manual efforts. The Proposed solution here works Using the Sensors. The Sensor used here for Sensing Purpose is an Infrared (IR) Sensor. The Sensor senses the presence of car and this data is now converted into the form which is understood by the Microcontroller and accordingly Microcontroller takes the Action. The Proposed System provides the better alternative for the protection of the car also its Specialty of being Automated Reduces a lot of time in Covering and Uncovering of Car [4].

2.5 Design and Analysis of an Innovative Umbrella for Car

The rising interior temperature is crucial for the comfort of the car's passengers. It also has an impact on the lifespan of many interior car items, including plastic and electronic components. Users hold off getting in the automobile to allow the interior to cool. One of the efficient alternatives to conventional vehicle covers and the covered parking spaces, which are only accessible in specific locations, is a car parking umbrella. Anywhere you go, you can carry a car umbrella to shield your vehicle from the sun's rays and the rain. The heating issue that arises when cars are parked in the sun or in an open place is fairly resolved by this research work. When parked, it can shield the car from the sun and rain [5].

2.6 Car Covers

Car cover is made of durable material. Provide safety from mold, mildew and environmental hazards. The properties of the cover are that it is strong and light weight and waterproof. The most important part for this cover is that your car antenna should be retractable and removable. For safety of cover its not allow to wash your cover in washing machine wash cover with mild liquid detergent in cold or warm water and clean the cover with sponge. This remote-controlled automobile roof cover's purpose is to shield the user's car from dust and precipitation. In order to accomplish automatic operation or control to lessen problems encountered during rain, this automation has been described as the combined use of mechanical and electronic systems. In the future, the system might be controlled by a process or run through a mobile application [6].

2.7 Remote Operated Car Covers

Since it is impossible to park a car in a secure location all the time, everyone needs a car cover that they may use to instantly cover their vehicle by pressing a switch without coming into contact with it. In this essay, the literature on remote-controlled car covers is reviewed. These covers can be activated by pressing a single remote key. This motor-driven cover includes a scissor mechanism that can expand and shrink and aids in quickly covering the entire automobile. It covers the entire vehicle in a flimsy yet durable cloth that shields it from numerous elements while it is parked, including sunlight, rain, dust, mud, and minor scratches [7].

2.8 Automated Car Cover

The main purpose of car cover is to protect car from dust and rain. So, the purpose of automated car cover is to make it ease of operation as two to three persons are required for covering a car by a cover which is already available in the market. And it makes direct contact with surface of car's body and produce scratches on the body of car. So that's why we are going to make a cover which automatically cover the whole car and didn't make direct contact with the surface of car's body to protect the surface of car from scratches. Despite of using it only for covering a car there are also many other applications where we use these automated mechanisms to cover

something for example we use it in garage, in the open area of mosques means such places whom we don't want to cover all the time [8].

2.9 IoT Full Protection Covers for Parked Car at Remote Stations

Technology becomes very advance these days and like transportation we are using vehicles for smooth and comfortable travelling. Due to which our car got a huge damage from the rain, hailing, UVs rays and muds. Many types of manual vehicle cover are used to protect the vehicle. Then we move toward the automatic cover in start there are so many components due to which if any one component fail to work so the whole system will fail. This is also operated by manual. The other system is like using sheet to protect from UVs rays and another system is automatic having motor but it is occupying a huge space and fixed to one place. So, there is continually progress this technology and they made a vehicle cover attached with car having both mechanical and electrical system to protect the vehicle and reduce the problem to cover the vehicle. Now the technology become advance but it also has drawn back like remote control cover will operate through some limited distance and work when we give command to it [9].

2.10 Review on Full Protection Covers for Parked Car at Remote Stations

Many types of manual vehicle cover are used to protect the vehicle. But these have many draws back like time consuming and difficult to operate by a single person. Then we move toward the automatic cover in start there are so many components due to which if any one component fail to work so the whole system will fail. This is also operated by manual not by giving command. In an automatic jacket for vehicle. They made an umbrella type cover which only protect the car from top. And it operates with a command and have a retractable mechanism. The other system is like using sheet to protect from UVs rays and another system is automatic having motor but it is occupying a huge space and fixed to one place. Now the technology become advance but it also has drawback like remote control cover will operate through some limited distance and work when we give command to it [10].

2.11 Translational Bar Mechanisms

Deployable structures have ability to change it shape and volume according to the needs. With the help of scissors mechanisms, we will fold the structure and save space. It can be chosen on the basis of the design of structure like the bar have same length and join to the midpoint for linear motion. By changing the length and distance from the midpoint we will make it different application like rise and arbitrary or arc shape etc. [11].

2.12 Two Planar Deployable Mechanisms

Expandable structures will change its shape and volume according to the design and applications. The main unit for a planar rectilinear deployable mechanism is the translational scissor unit it's joins from the center and have same length by increasing or decreasing the height of the bars we will change it length. So, we can easily use this mechanism according to our design requirement by calculating its parameter [12].

2.13 Angulated Scissor Structures

Primary scissor units have different scissor structures. So, we can make it according to the requirement. The scissor structures can change their shapes between two predefined geometries, the hinges of the unit lie on either a straight path or a curve path during the deployment process. With different bar length and at different angle we can control the shape of the mechanisms. Like arc shape semicircular and arbitrator [13].

2.14 Parametric Evaluation of Deployable Scissor Arches

The scissor structure mechanism can easily retract able and control by the automation system and it will operate in linear motion polar and angulated type by changing the height length and angle of the mechanisms the midpoint will help to give the shape direction. This paper begins by introducing the research methodology and considered design parameters, a sensitivity analysis of the design parameters is performed. The latter forms the basis of an exhaust parametric structural study. Based on the research we can design the mechanism according to the parameter [14].

2.15 Geometric Principles and Design Methods

The scissor structural unit consist of the straight bars the length will depend on the basis of the design calculation.it have three main type translational in this the mechanism show the linear motion the next type is polar it is formed by joining the tow straight bars way from the midpoint. The last type is angular in these two identical angulated bars are used rather than straight bars. With the help of this research, we can make the fold able system [15].

2.16 Inclined Iron Core Linear Electric Motor

Motor is important to control and automate the system that's why the linear motor is used with the help of the bearing to provide the torque and the force which help to design the automatic system. Motor is the basic component for any automated system it will help to control the motion of the system or the machine to operate it at best efficiency we need to calculate the design the required parameter for the automatic system. And to install the motor with the system we need some other components like bearing shaft and fastener [16].

2.17 Linear Motion Stage Systems

In this paper we have the characteristic analysis and experiment of pitching moment in a high-precision permanent magnet linear synchronous motor (PMLSM). This system has very high positioning and low error. The normal and tangential components of the flux density distribution in the middle of the air gap that's why the analytical solutions generated by permanent magnets (PMs) for magnetic field and calculation in terms of the polar coordinate system [17].

CHAPTER THREE: RESEARCH DESIGN

Our project is an automatic retractable car cover to make this cover it is important to know about the cars for that we start our research on the cars as the important parameter for making the car cover is the dimensions of the car that's why we collected the data about cars present in Pakistan and their dimensions which help in the design of the frame for an automatic car cover.

3.1 Dimension Selection for Car

Below are the tables we make on the basis of our research. All cars dimensions' tables are in millimeters (mm).

3.1.1 Hatchback cars dimensions

This is the table we make on the basis of our research in which different hatchback car models with their dimensions are available. The maximum length is 3845 mm of Suzuki Swift and minimum length is 3300 mm of Suzuki Mehran. The maximum width is 1735 mm of Suzuki Swift as show in figure 3.2 and minimum width is 1405 mm of Suzuki Mehran as show in figure 3.1. The maximum Height is 1780 mm of Honda N Box and minimum height is 1410 mm of Suzuki Mehran show in figure 3.1.

Table 3.1 Dimensions table of Hatchback car

Car Models	Length (mm)	Width (mm)	Height (mm)
Suzuki Mehran	3300	1405	1410
Suzuki Alto	3445	1515	1475
Suzuki wagon R	3635	1600	1675
Suzuki cultus	3635	1620	1540
Suzuki Swift	3845	1735	1530
Honda N One	3395	1475	1610
Honda N Wgn	3395	1475	1655
Honda N Box	3395	1475	1780
Toyota Vitz	3750	1695	1505
Toyota passo	3595	1665	1535
United Bravo	3350	1590	1530
Prince Pearl	3610	1570	1490
Kia Picanto	3595	1595	1490



Figure 3.1: Dimension of Suzuki Mehran [21]



Figure 3.2: Dimension of Suzuki Swift [21]

3.1.2 Sedan cars dimensions

This is the table we make on the basis of our research in which different sedan car models with their dimensions are available. The maximum length is 4885 mm of Toyota Cammry show in figure 3.4 and minimum length is 3995 mm of Suzuki Ciaz. The maximum width is 1840 mm of Toyota Cammry and minimum width is 1689 mm of Proton Saga. The maximum Height is 1510 mm of Suzuki Ciaz and minimum height is 1433 mm of Honda Civic.

Table 3.2 Dimensions table of Sedan cars

Car models	Length (mm)	Width (mm)	Height (mm)
Toyota Yaris	4425	1730	1495
Toyota Cammry	4885	1840	1455
Toyota Belta	4300	1700	1480
Toyota Crown	4728	1839	1460
Toyota Prius	4540	1760	1490
Toyota Corolla	4620	1775	1475
Honda Civic	4656	1799	1433
Honda City	4549	1748	1489
Hyundai Elantra	4620	1800	1465
Hyundai Sonata	4820	1830	1490
Suzuki Ciaz	3995	1745	1510
Changn Alsvin	4360	1710	1475



Figure 3.3: Dimension of Honda City [21]



Figure 3.4: Dimension of Toyota Camry [21]

3.1.3 SUVs cars dimensions

This is the table we make on the basis of our research in which different SUVs car models with their dimensions are available.

Table 3.3 Dimensions table of SUV cars

Car model	Length (mm)	Width (mm)	Height (mm)
Toyota Revo/Hilux	5325	1855	1815
Toyota fortuner	4795	1855	1835
Toyota Landcruiser Prado	4850	1855	1850
Landcruiser V8	4950	1981	1879
Honda BR-V	4453	1735	1666
Honda CR-V	4625	1854	1684
Honda HR-V	4335	1790	1590
Suzuki Jimny	3550	1645	1730
Kia Sportage	4480	1854	1640
Kia Sorento	4800	1890	1685
Hyundai Tucson	4665	1865	1665
MG HS	4574	1876	1664
MG ZS	4314	1809	1620
HAVAL Jolion	4472	1841	1619
HAVAL H6	4653	1886	1724
CHANGAN Oshan X7	4705	1860	1720
Glory580pro	4680	1845	1715
Proton X70	4519	1831	1694
Peugeot 2008	4159	2004	1556
BAIC BJ40	4350	1843	1834



Figure 3.5: Dimension of Suzuki Jimny [21]



Figure 3.6: Dimension of Toyota Land cruiser [21]

The maximum length is 5325 mm of Toyota Revo/Hilux and minimum length is 3550 mm of Suzuki Jimny show in figure 3.5. The maximum width is 2004 mm of Peugeot 2008 and minimum width is 1645 mm of Suzuki Jimny. The maximum Height is 1879 mm of Landcruiser V8 and minimum height is 1556 mm of Peugeot 2008.

3.1.4 Selection Category

In start we think to make a car cover which cover all the cars but after the research we find out a huge difference in the cars dimensions like the minimum length is 3300 mm of Suzuki Mehran show in figure 3.1 and the maximum length is 5325 mm of Toyota Revo/Hilux and minimum width is 1405 mm of Suzuki Mehran as show in figure 3.1. The maximum width is 2004 mm of Peugeot 2008 and minimum height is 1410 mm of Suzuki Mehran show in figure 3.1 and the maximum Height is 1879 mm of Landcruiser V8. It is difficult to make an economy wise car cover which cover all the cars that's why we decided to make the car cover which will cover at least one type of car category this is our final year project that's why we chose to make an automated retractable car cover for hatchback cars.

3.2 Pipe Selection for Car Frame

After that we need the dimension of the pipes which we use for the frame. We decided to choose the steel pipe of schedule # 40. So, we concern the table of stainless-steel pipe schedule 40 which is available on internet. Stainless steel is an alloy of iron, chromium, and, occasionally, nickel and other metals that resists corrosion. Stainless steel is the ultimate "green material" because it is completely and essentially recyclable. In reality, the recovery rate for the building industry is quite close to 100%.

A very strong metal, stainless steel can survive all kinds of strikes that would otherwise cause serious harm. This metal is strong and resistant to corrosion in alkaline solutions and chlorine-containing conditions. It can also tolerate extreme heat and temperatures well below freezing.

3.2.1 Stainless Steel Schedule 40 Pipes Dimension

Table 3.4 Dimensions of SS (Stainless Steel) Pipe [22]

Nominal size [inches]	Outside diameter [inches]	Outside diameter [mm]	Wall thickness [inches]	Wall thickness [mm]
1/2	0.840	21.3	0.065	1.65
3/4	1.050	26.7	0.065	1.65
1	1.315	33.4	0.065	1.65
1 1/4	1.660	42.2	0.065	1.65
1 1/2	1.900	48.3	0.065	1.65
2	2.375	60.3	0.065	1.65

3.3 Modeling in Solid work

From the above research we will design a frame for the car cover which is adjustable to cover all the cars for same category. Below are the images of frame which we make on the solid work.

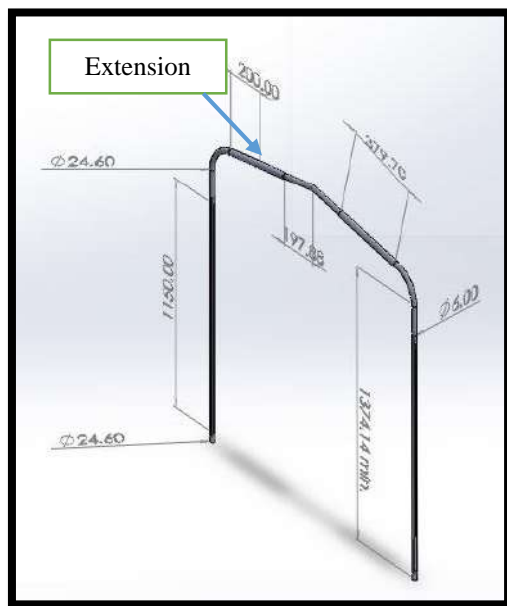


Figure 3.7: Frame of Hatch back car cover (mm)

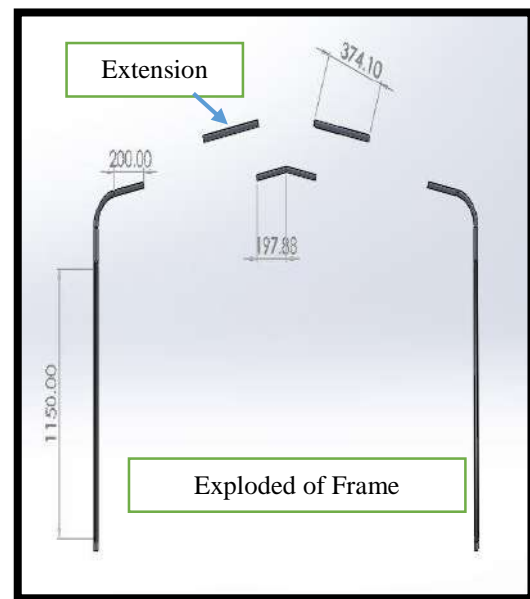


Figure 3.8: Exploded view of Hatch Back frame (mm)

3.3.1 Frame Components

In this frame we have three main components. For the first component, we use the line, circle, fillet radius, exclude, exclude cut, and sweep command. First, we draw a line in L shape then give the correct dimensions then use the fillet radius command to give the arc shape between the point of 2 line and make a small angle to the both line due to which we create a slope. Then we use the sweep command to create the body of the frame then we use the exclude and exclude cut command to make hole and shape of the frame.

For the second components, we use the circle and exclude command. First, we draw a 2 circle with required diameter and then exclude it to required length.

For the third component, we used the line, and sweep command. First, we use the line command to draw the 2 lines then use the sweep command to give it 3D shape.

3.4 Mechanism Selection

After completing the assembly of the frame, we move on the mechanisms which help us in the automation of the system so we start our research about the mechanism which give the linear motion. So, we can use the mechanism between the frames and it will become retractable. So, we find the scissor bar mechanism suitable for our project. Whose details are given below.

We are working on a retractable linear motion mechanism which is the main part of our car cover through which we cover the full car easily. We chose rectilinear scissor structural mechanisms it is a translational unit Consisting of straight bars, rectilinear SSMs can only translate without any rotation.

For installing of these mechanisms, it is important that all the unit are lines parallel to each other. With respect to the location and length of the bar. We have different type of rectilinear SSMs.

- The first kind of rectilinear SSM is made up of SUs with identical bars and scissor joints at the middles of the bars as show in Figure 3.9.

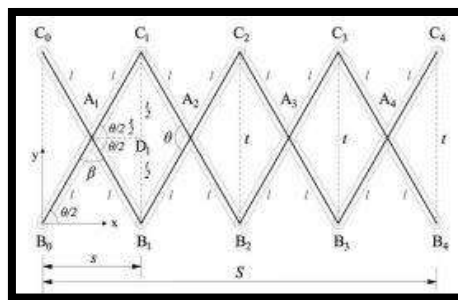


Figure 3.9: Identical Bars SSMs [23]

- The second type of rectilinear SSM consists of SUs with various bar lengths, but once more the scissor hinge is located at the middle of the bars as show in Figure 3.10.

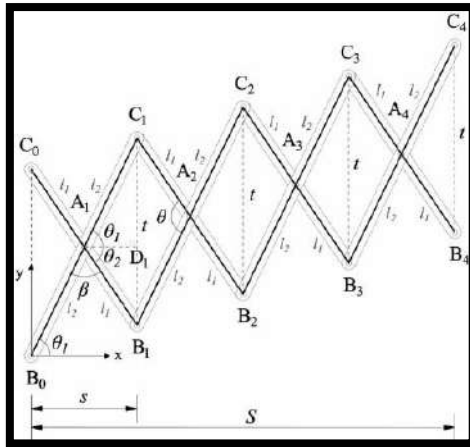


Figure 3.10: Different Bars Length SSMs [23]

- The third type has varied bar lengths for each SU and, like the second type, the scissor hinge is located at the midpoints of the bars as show in Figure 3.11.

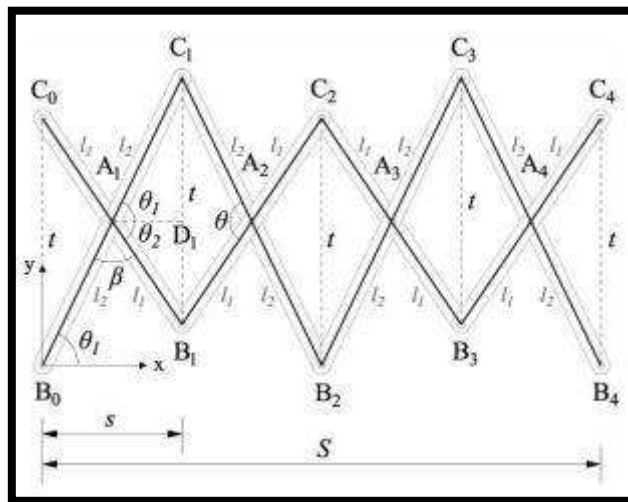


Figure 3.11: Different Bars Length joint at Mid-Point SSMs [23]

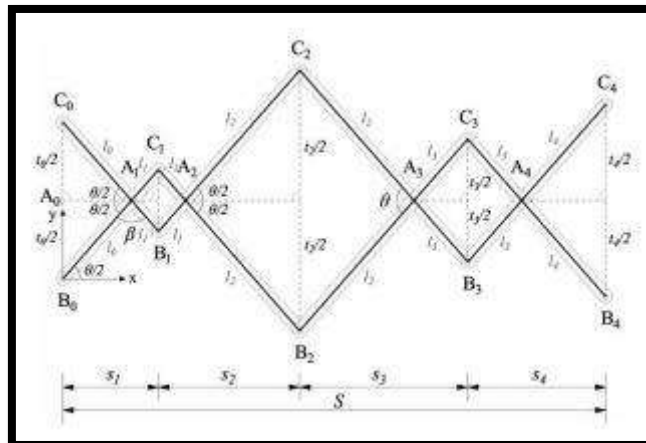


Figure 3.12: Arbitrary bar lengths SSMs [23]

- The fourth type of rectilinear SSM has arbitrary bar lengths and an eccentrically positioned scissor hinge. Each unit of this type has a varied bar length and a randomly placed scissor hinge as show in Figure 3.12.

We use the first type of rectilinear SSMs having identical bars and attached with midpoint. To make this rectilinear SSMs for our desire requirement we calculate the few parameters which are the following:

- Height of mechanism (t).
- Length of mechanism (S).
- Number of scissor (N).
- Height of bar (t).
- Length of bar (2L).
- (θ) Angle between to bars parallel to y axis.
- (β) Angle between to bars parallel to x axis.

3.5 Mechanism Calculations

To calculate these parameters we need some equation which are given bellow. We also find the coordinates of the Nth SUs by x_{BN} , x_{CN} , y_{BN} , y_{CN} .

By using equation 1 we calculate out the angle(θ).

$$S = 2L \cos \frac{\theta}{2} \quad (1)$$

By using equation 2 we calculate the Number of scissor (N).

$$N = S/s \quad (2)$$

By using equation 3 we calculate out the angle(β).

$$\beta = \cos^{-1} \left(1 - \frac{s^2}{2L^2} \right) \quad (3)$$

By using equation 4 we calculate the Height of bar (t).

$$t = 2 \sqrt{L^2 - \frac{s^2}{4}} \quad (4)$$

By using equation 5 we calculate the coordinate of the scissor.

$$x_{BN} = x_{CN} = N2L \cos \frac{\theta}{2} \quad (5)$$

By using equation 6($y_{BN} = 0$)

$$y_{BN} = 0 \quad (6)$$

By using equation 7 we calculate the coordinate of the scissor.

$$y_{CN} = 2L \sin \frac{\theta}{2} \quad (7)$$

These parameters are given, based on our research and our project requirement. We use these equations to calculate the unknown parameter.

S=4.2m

s=1.05m

N=4

L=0.6

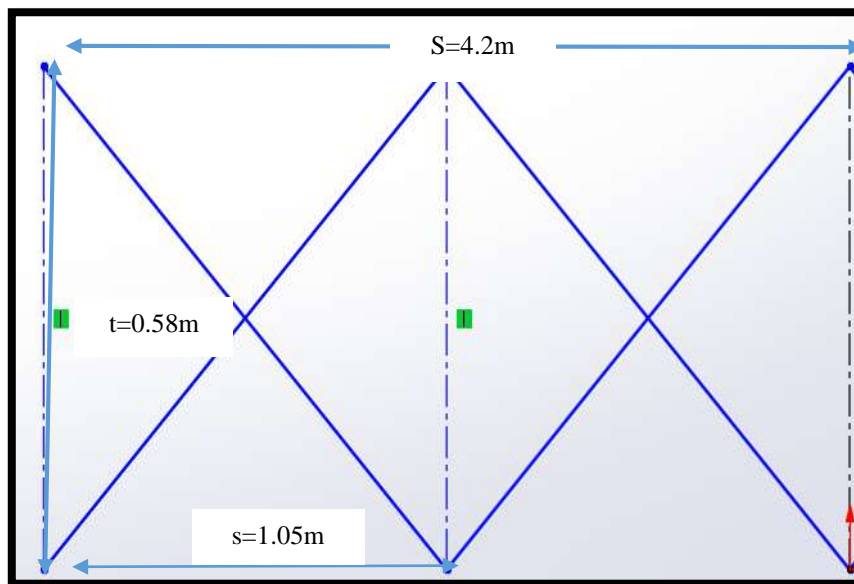


Figure 3.13: Rectilinear scissor mechanism for Automatic car cover

First of all, we find the angle between the 2 bars.

From using equation 1 we calculated $\theta = 57.9^\circ$

$$\theta = 2 \cos^{-1} \frac{s}{2L}$$

$$\theta = 2 \cos^{-1} \frac{1.05}{2(0.6)}$$

$$\theta = 57.9^\circ$$

From using equation 3 we calculated $\beta = 122^\circ$

We find the second angle beta and the sum of the theta and beta equal to 180 degrees due to straight line angle.

$$\beta = \cos^{-1}\left(1 - \frac{s^2}{2L^2}\right)$$

$$\beta = \cos^{-1}\left(1 - \frac{(1.05)^2}{2(0.6)^2}\right)$$

$$\beta = 122^\circ$$

We calculate the height of the mechanism by using equation 4

$$t = 2 \sqrt{L^2 - \frac{s^2}{4}}$$

$$t = 2 \sqrt{(0.6)^2 - \frac{(1.05)^2}{4}}$$

$$t = 0.58m$$

We calculate the position of the nth scissor according to coordinate by the given equation 5 and 6.

$$x_{BN} = x_{CN} = N2L \cos \frac{\theta}{2}$$

$$x_{BN} = x_{CN} = (4)2(0.60) \cos \frac{57.9}{2}$$

$$x_{BN} = x_{CN} = 4.2m$$

$$y_{CN} = 2L \sin \frac{\theta}{2}$$

$$y_{CN} = 2(0.6) \sin \frac{57.9}{2}$$

$$y_{CN} = 0.58m$$

These parameters are important for the modeling of the rectilinear SSMs for over car cover.

Now we are going to find the parameters for double scissor structural mechanism.

$$S=4.2m$$

$$s=0.025m$$

$$N=8$$

$$L=0.3$$

First of all, we find the angle between the 2 bars.

From using equation 1 we calculated $\theta = 57.9^\circ$

$$\theta = 2 \cos^{-1} \frac{s}{2L}$$

$$\theta = 2 \cos^{-1} \frac{0.025}{2(0.3)}$$

$$\theta = 57.9^\circ$$

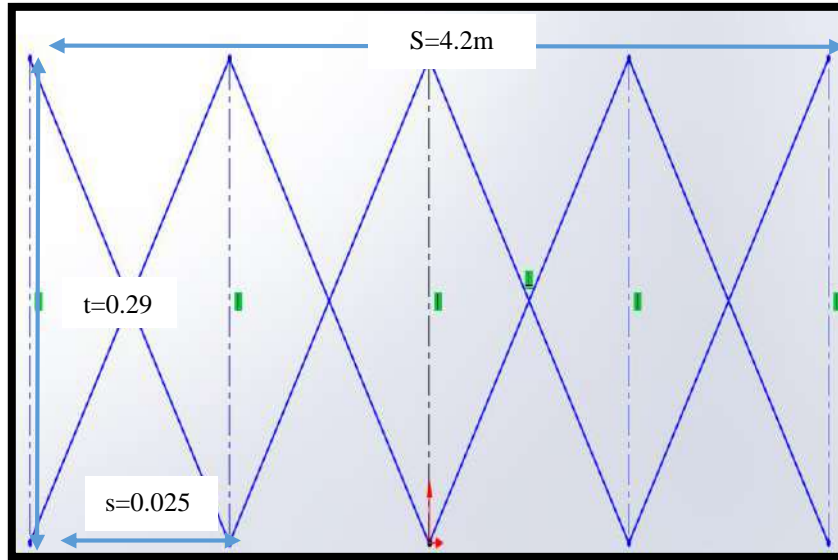


Figure 3.14: Rectilinear double scissor Mechanism for Automatic Car cover

From using equation 3 we calculated $\beta = 122.1^\circ$

We find the second angle beta and the sum of the theta and beta equal to 180 degrees due to straight line angle.

$$\beta = \cos^{-1} \left(1 - \frac{s^2}{2L^2} \right)$$

$$\beta = \cos^{-1} \left(1 - \frac{(0.025)^2}{2(0.3)^2} \right)$$

$$\beta = 122.1^\circ$$

We calculate the height of the mechanism by using equation 4

$$t = 2 \sqrt{L^2 - \frac{s^2}{4}}$$

$$t = 2 \sqrt{(0.3)^2 - \frac{(0.025)^2}{4}}$$

$$t = 0.29m$$

We calculate the position of the nth scissor according to coordinate by the given equation 5 and 6.

$$x_{BN} = x_{CN} = N2L \cos \frac{\theta}{2}$$

$$x_{BN} = x_{CN} = (8)2(0.3 \cos \frac{57.9}{2})$$

$$\mathbf{x_{BN} = x_{CN} = 4.2m}$$

$$y_{CN} = 2L \sin \frac{\theta}{2}$$

$$y_{CN} = 2(0.3) \sin \frac{57.9}{2}$$

$$\mathbf{y_{CN} = 0.29m}$$

In order to scale down the ratio by 1/3, we find out the desired dimension for project.

$$\mathbf{S=1.21m}$$

$$\mathbf{s=0.0275m}$$

$$\mathbf{N=8}$$

$$\mathbf{L=0.3}$$

First of all, we find the angle between the 2 bars.

From using equation 1 we calculated $\theta = 125.4^\circ$

$$\theta = 2 \cos^{-1} \frac{s}{2L}$$

$$\theta = 2 \cos^{-1} \frac{0.0275}{2(0.3)}$$

$$\mathbf{\theta = 125.4^\circ}$$

From using equation 3 we calculated $\beta = 54.6^\circ$

We find the second angle beta and the sum of the theta and beta equal to 180 degrees due to straight line angle.

$$\beta = \cos^{-1} \left(1 - \frac{s^2}{2L^2} \right)$$

$$\beta = \cos^{-1} \left(1 - \frac{(0.0275)^2}{2(0.3)^2} \right)$$

$$\mathbf{\beta = 54.6^\circ}$$

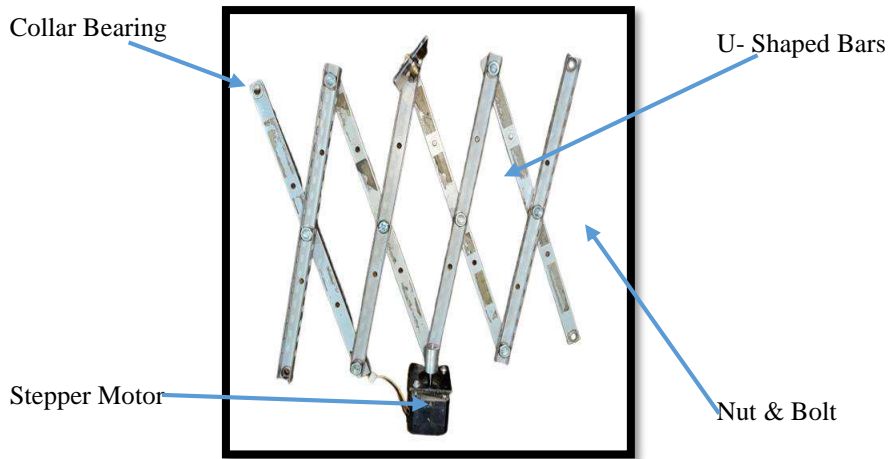


Figure 3.15: Actual Scissor Mechanisms for Automatic car cover

We calculate the height of the mechanism by using equation 4

$$t = 2 \sqrt{L^2 - \frac{s^2}{4}}$$

$$t = 2 \sqrt{(0.3)^2 - \frac{(0.0275)^2}{4}}$$

$$t = 0.265m$$

We calculate the position of the nth scissor according to coordinate by the given equation 5 and 6.

$$x_{BN} = x_{CN} = N2L \cos \frac{\theta}{2}$$

$$x_{BN} = x_{CN} = (8)2(0.3) \cos \frac{125.4}{2}$$

$$x_{BN} = x_{CN} = 2.2m$$

$$y_{CN} = 2L \sin \frac{\theta}{2}$$

$$y_{CN} = 2(0.3) \sin \frac{152.4}{2}$$

$$y_{CN} = 0.265m$$

3.6 Mechanism Modeling in Solid work

After the calculation we model the scissor structural mechanism. In which we use line, rectangular, circle, exclude and exclude cut command. First of all, we draw a rectangular and then exclude it then we use the circle command and exclude cut command to make three holes.

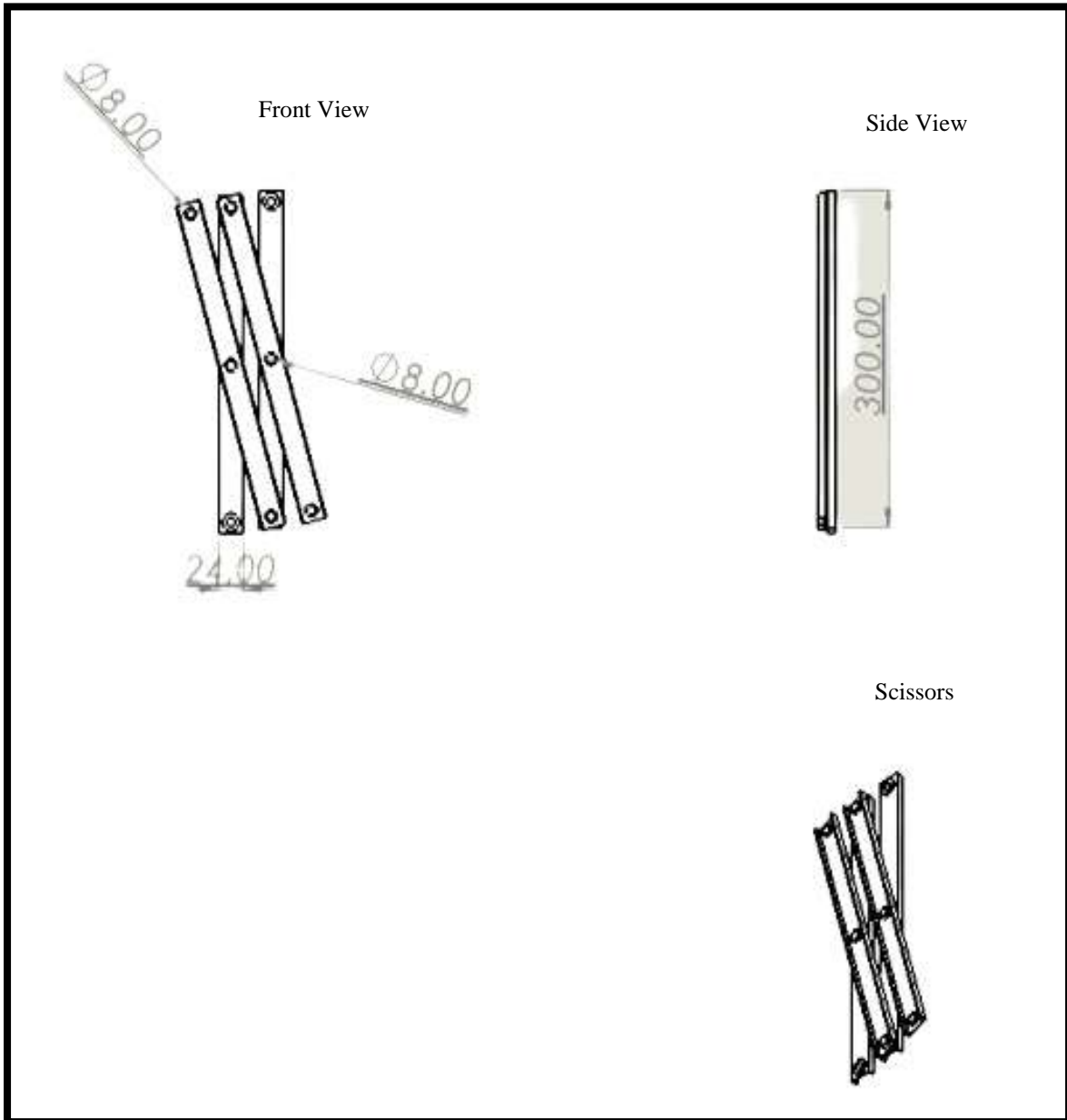


Figure 3.16: Retractable Design for double Bars of Scissor Structural Mechanisms (mm)

Then we make the assembly of the scissor by using the 2 commands insert component and mate command. We use the same bar for the assembly because our SSMs requirement that the bars are identical.

3.7 Combination of Frame & Mechanism

There is combination of frame and Assembly. We used total no. of 5 frames that will expand or contract through mechanisms which is called RSSMs (Rectilinear Scissor Structural Mechanisms). We used 4 scissor that will close or open the frame. For making this combination, we made model on solid work. In solid work, we different command like as mate, insert, slot, rectangular, circle, line and sweep commands.

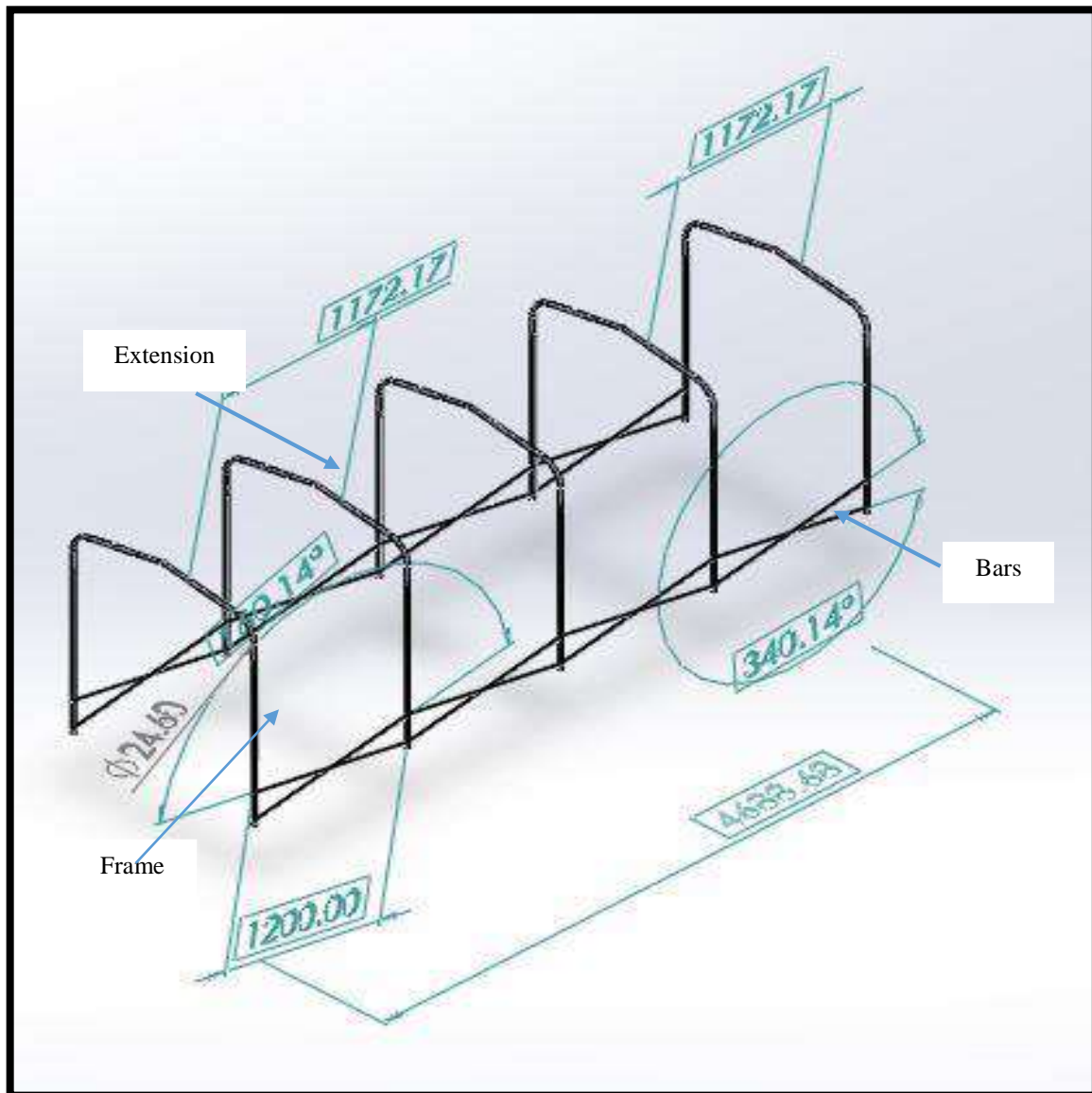


Figure 3.17: Model of Frame & Scissor Bars (mm)

From table (3), we take dimensions of Suzuki swift that is about 1500 mm height and 4400 mm length. From calculations, we take the height of mechanism is 580 mm and length of mechanism is 4400 mm. This mechanism will move to and fro the frame which will make adjustable for all hatchback cars.

3.7.1 Exploded view of Frame & Mechanism

Here is exploded view of frame and scissor. There are 4 scissor and 5 frame which are exploded in the figure 3.18. This combination will be motorized and easily open and close by just pushing the button. We will need a control system to operate the motor, such as a microcontroller or a relay. We can use a switch or a remote control to trigger the control system. The frame help us to maintain the safe distance from the car and scissor will help us in the opening and closing of the frame.

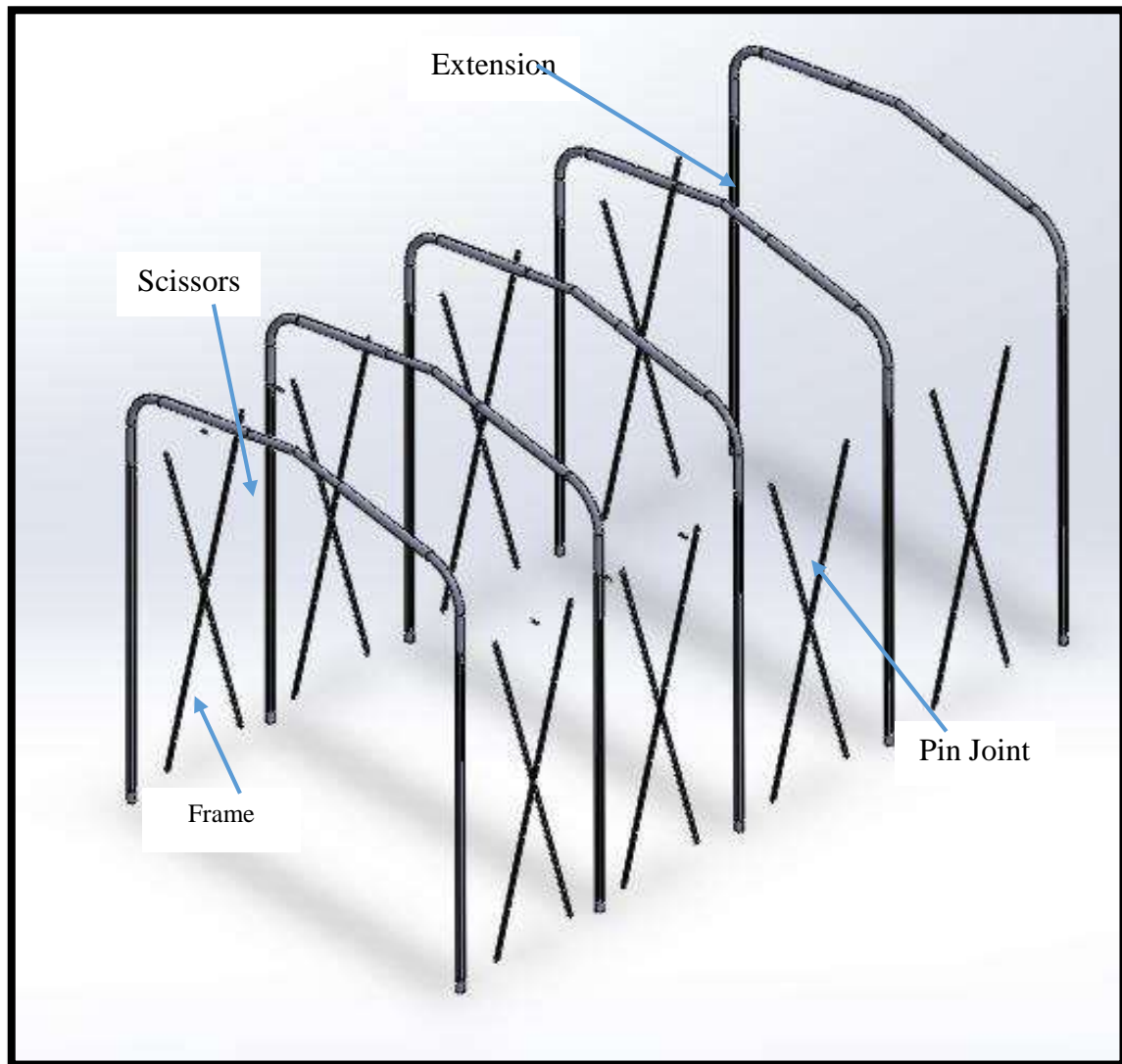


Figure 3.18: Exploded view of Frame & Scissor Structural Mechanism

3.7.2 Caster Wheel

Here is caster wheel which consists of top plate, fork, wheel, axle nut and axle bolt. We will have used caster for the expansion and contraction of frame. It will help for the opening and closing of the system smoothly because it will reduce the friction between the floor and the frame so less torque is required to the motor for the opening and closing of the full system because the friction is reduced by using wheel.

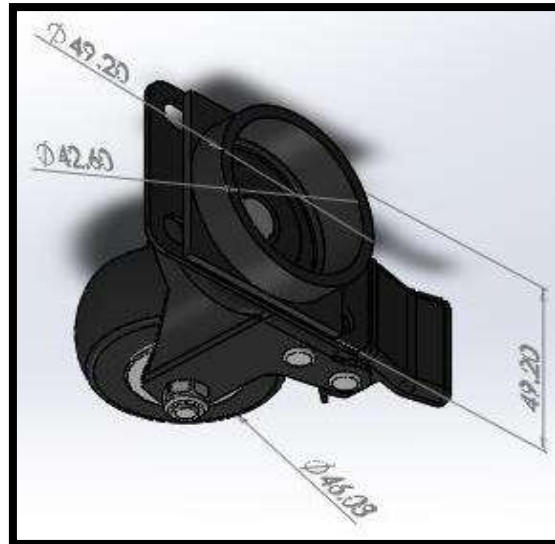


Figure 3.19: Caster Wheel (mm)

3.8 Final Assembly of RCC

Here is the final assembly of RCC (Retractable car cover) which consists of three main components. These three components are frame, scissor, and caster. This mechanism will be automated through motors.

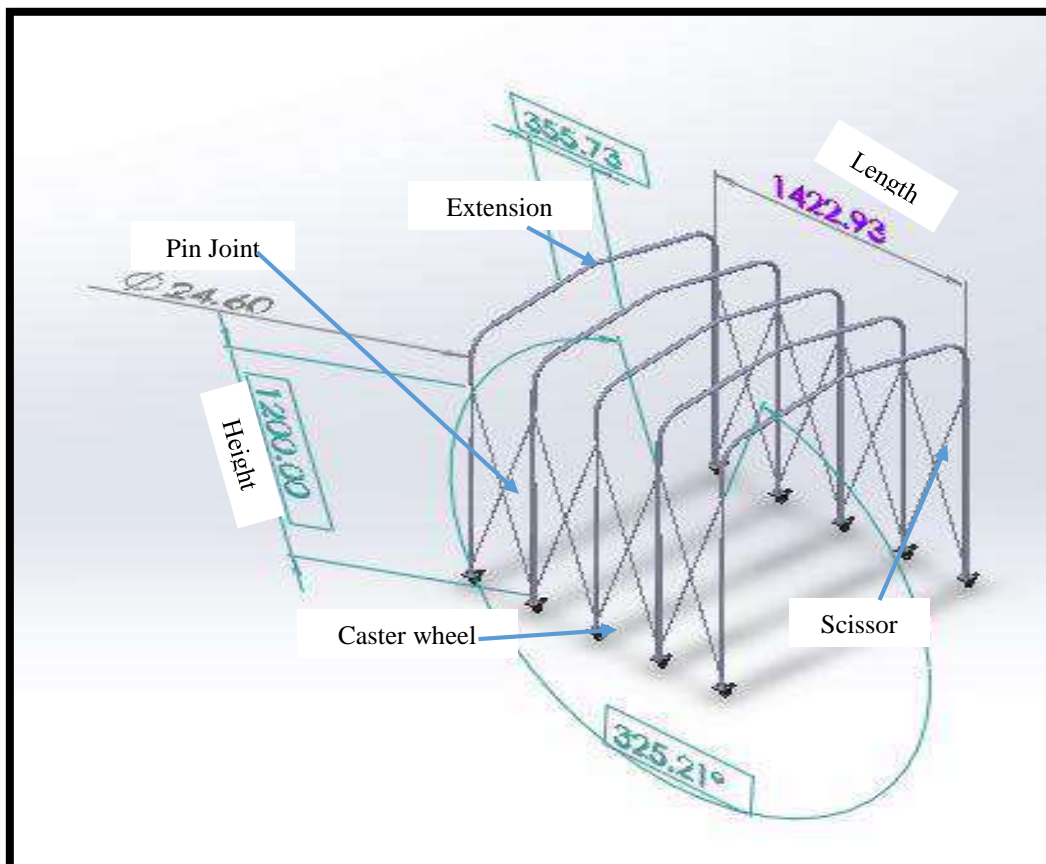


Figure 3.20: Final Assembly of Retractable car cover (mm)

We will have used two motors at the fixed frame. The motor is connected to the cover through a mechanical drive system, such as a belt or a chain, which transfers the rotary motion of the motor to linear motion, allowing the cover to move in and out. The motor is controlled by a control system, which can be a microcontroller, a relay, or a switch. The control system activates the motor to open or close the cover based on input from the user, such as a switch or a remote control.

3.8.1 Contraction of RCC

When the frame is fully contracted, the maximum length is 1105 mm or 1.1m and scissor height is 1.2 m as show in the figure 3.21. The contraction of a retractable frame refers to the process of reducing the size or length of the frame. Retractable frames typically use a motor, control system, and drive mechanism to contract the frame. When the user activates the control system, the motor rotates, turning the drive mechanism, which pulls the frame into a more compact position.

3.8.2 Expansion of RCC

When the frame is fully expended, the maximum length is 4739 mm and maximum distance between two frame is 1184 mm as show in figure 3.22. so it can be adjustable frame for all catergories of retractable car cover. The expansion of a retractable frame refers to the process of increasing the size or length of the frame.

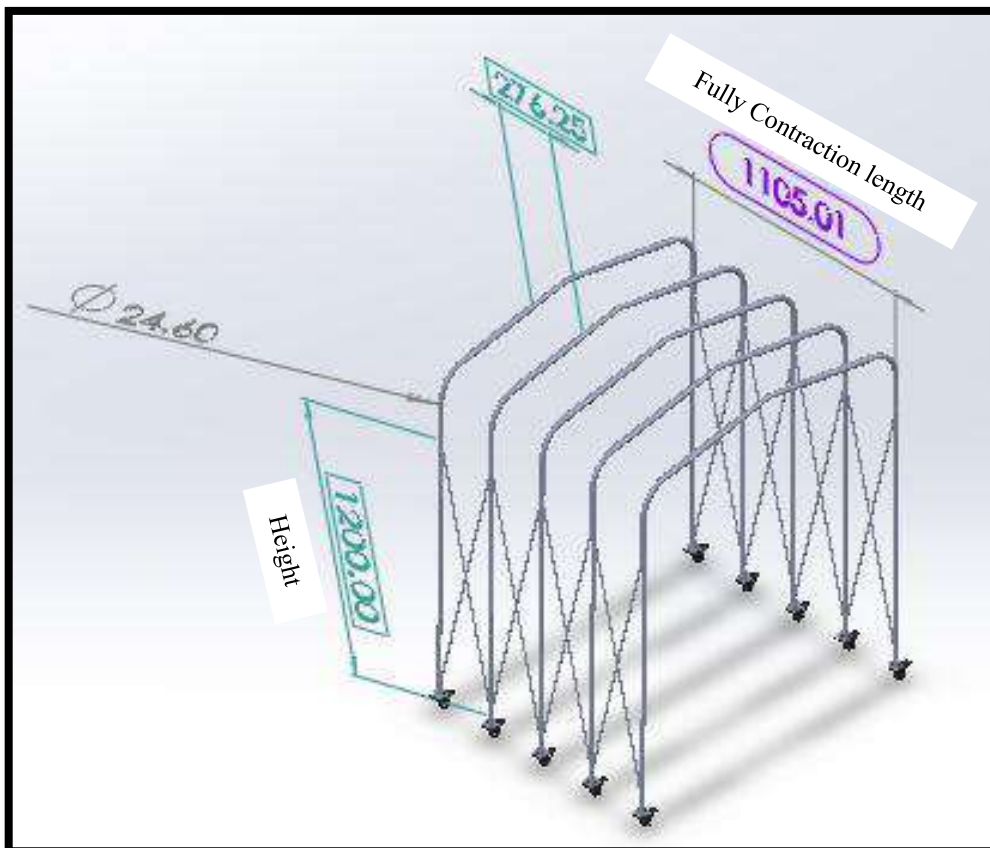


Figure 3.21: Folded form of Retractable car cover (mm)

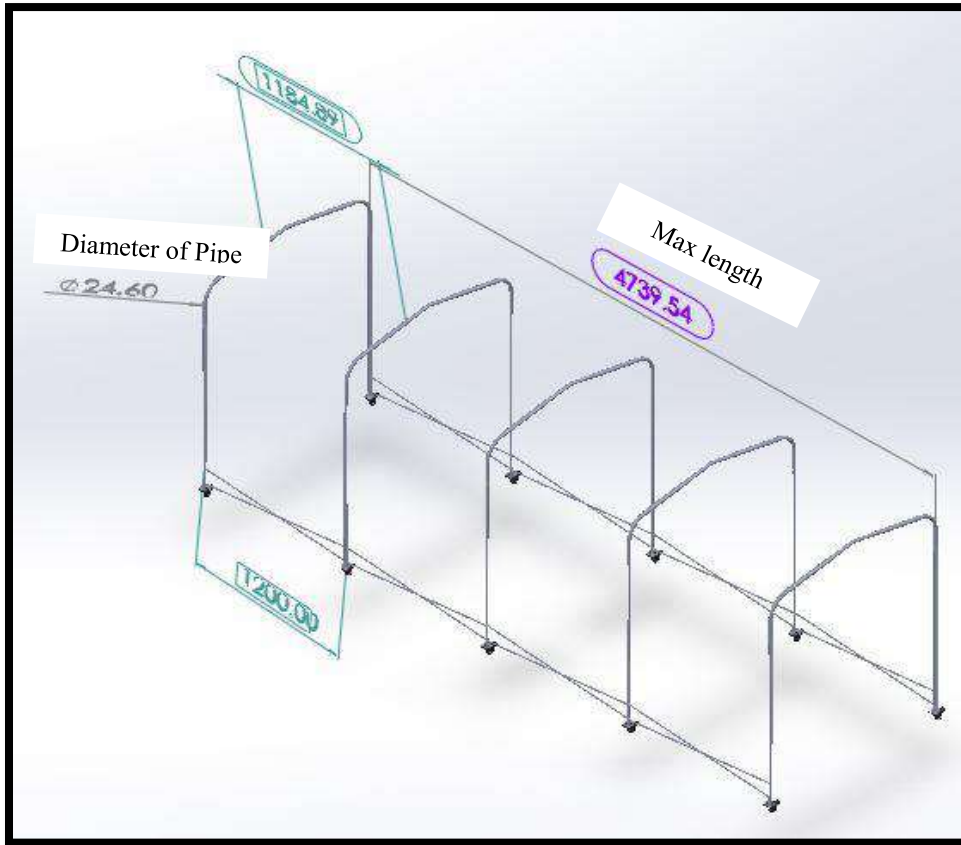


Figure 3.22: Dimension of full opened orientation of car cover (mm)

In the context of a retractable car cover, expansion typically refers to the process of extending the cover, which involves increasing the length of the frame to its full, deployed position. The speed and smoothness of the expansion process depend on the design of the drive mechanism, the power of the motor, and the stability of the frame.

CHAPTER FOUR: FABRICATIONS

In this chapter, we fabricate our projects. For fabrications we used different components to fabricate retractable car covers. The fabrication process of a retractable car cover involves several steps to ensure functionality, durability, and ease of use. Firstly, high-quality, weather-resistant materials are selected, such as strong yet lightweight fabrics and sturdy metal components. The chosen fabric undergoes cutting and stitching to create the main body of the cover, with reinforced edges and seams for added strength. Then, a framework is constructed, typically using lightweight aluminum, Iron or steel, which will support the cover and allow for smooth retraction and extension. The cover is then attached to the framework, utilizing hooks, clips, or a track system that enables smooth sliding and locking mechanisms. For control the cover's functionality, additional features may be integrated, such as remote-controlled operation, built-in sensors for automatic expand and contract the cover. Lastly, we will perform testing procedures which are conducted to ensure the mechanism is retractable, provides adequate coverage, and withstands various environmental conditions.

4.1 Car Cover Materials

Table 4.1 Car Covers Materials

Car covers	Properties	Drawbacks	Available	Price (Pkr)
POLYESTER	<input type="checkbox"/> Water-resistant <input type="checkbox"/> UV-resistant <input type="checkbox"/> Breathable <input type="checkbox"/> Scratch-resistant <input type="checkbox"/> Easy to clean <input type="checkbox"/> high resistance to temperature <input type="checkbox"/> more expensive	<input type="checkbox"/> fewer risks of accidental scratching or denting due to how it has been constructed with fiberglass woven into the polyester <input type="checkbox"/> Fading and discoloration	<i>Yes</i>	<i>1,500 to 3,000</i>
POLYPROPYLENE	<input type="checkbox"/> Lightweight <input type="checkbox"/> Water-resistant <input type="checkbox"/> Non scratches <input type="checkbox"/> Durable <input type="checkbox"/> UV-resistant <input type="checkbox"/> Easy to clean <input type="checkbox"/> Less expensive	<input type="checkbox"/> Limited protection against harsh weather conditions like heavy rain, snow, or hail	<i>Yes</i>	<i>800 to 3,000</i>
POLY COTTON	<input type="checkbox"/> Water resistance <input type="checkbox"/> Durability <input type="checkbox"/> UV protection: <input type="checkbox"/> Softness: <input type="checkbox"/> Breathability	<input type="checkbox"/> Used for indoor car covers <input type="checkbox"/> Not fully waterproof <input type="checkbox"/> Produced scratches	<i>Yes</i>	<i>2,000 to 8,000</i>

POLYMICRO FIBRE	<input type="checkbox"/> Water resistance <input type="checkbox"/> Durability <input type="checkbox"/> UV protection: <input type="checkbox"/> Softness <input type="checkbox"/> Non-scratches <input type="checkbox"/> Easy to clean	<input type="checkbox"/> less resistant to abrasion <input type="checkbox"/> More expensive than another car covers	<i>Yes</i>	<i>5000 to 15,000</i>
IMITATION STAIN	<input type="checkbox"/> Attractive appearance <input type="checkbox"/> Water resistance <input type="checkbox"/> Durability <input type="checkbox"/> UV protection: <input type="checkbox"/> Softness: <input type="checkbox"/> Breathability	<input type="checkbox"/> Difficult to clean <input type="checkbox"/> Not ideal for extreme weather <input type="checkbox"/> Most expensive	<i>Yes</i>	<i>5,000 to 15,000</i>
PLASTIC COVER	<input type="checkbox"/> Affordable <input type="checkbox"/> Lightweight <input type="checkbox"/> Waterproof <input type="checkbox"/> Transparent	<input type="checkbox"/> Lack of breathability <input type="checkbox"/> Poor UV resistance: <input type="checkbox"/> Non-durable <input type="checkbox"/> Produced scratches	<i>Yes</i>	<i>500 to 2000</i>
WOOL CAR COVER	<input type="checkbox"/> Excellent Protection <input type="checkbox"/> Breathable <input type="checkbox"/> Non-scratches	<input type="checkbox"/> Produced starches <input type="checkbox"/> Not Waterproof <input type="checkbox"/> Not UV Resistant	<i>Yes</i>	<i>1000 to 2000</i>
PARACHUTE COVER	<input type="checkbox"/> Affordable <input type="checkbox"/> Lightweight <input type="checkbox"/> Water-Resistant	<input type="checkbox"/> Not Durable: <input type="checkbox"/> Not UV Resistant <input type="checkbox"/> Produced scratches	<i>Yes</i>	<i>1300 to 2000</i>

A polyester car cover is a popular choice for vehicle protection due to its durability and weather-resistant properties. Constructed from high-quality polyester fabric, these covers provide a reliable barrier against harmful elements such as UV rays, rain, snow, dust, and dirt. Polyester is known for its strength, making the car cover resistant to tears and abrasions. Additionally, polyester car covers are lightweight and easy to handle, allowing for effortless installation and removal. With their breathable nature, these covers help prevent moisture buildup, reducing the risk of mold and mildew. Polyester car covers are available in a variety of sizes and styles to fit different vehicle types, ensuring a snug and secure fit. Whether parked

indoors or outdoors, a polyester car cover offers reliable protection and peace of mind for car owners.

A polypropylene car cover is a popular choice for protecting vehicles against a range of environmental factors. Polypropylene is a lightweight yet durable material that provides excellent resistance to water, UV rays, dust, and dirt. These car covers are known for their exceptional breathability, allowing moisture and condensation to escape, preventing mold and mildew formation. Polypropylene car covers are easy to handle and install, making them convenient for everyday use. They offer a snug fit and can withstand harsh weather conditions, including rain, snow, and intense sunlight. With their affordability and reliability, polypropylene car covers are a practical option for keeping vehicles clean, protected, and well-maintained.

A poly-cotton car cover combines the best of both worlds, blending the durability of polyester with the softness and breathability of cotton. This unique blend of materials makes poly-cotton car covers an excellent choice for protecting vehicles. The polyester component provides strength, making the cover resistant to tears and abrasions, while the cotton element offers a gentle touch against the car's surface. Poly-cotton car covers offer reliable protection against UV rays, dust, dirt, and light rain. The breathable nature of the fabric helps prevent moisture buildup and allows air circulation, reducing the risk of mold and mildew. With their combination of strength, softness, and breathability, poly-cotton car covers provide a balanced solution for safeguarding vehicles while maintaining a clean and well-kept appearance.

A poly microfiber car cover is a top-notch choice for protecting vehicles with its advanced properties. Constructed from a blend of polyester and microfiber materials, this type of car cover offers outstanding durability and exceptional softness. The polyester component ensures strength and resistance to tears, while the microfiber adds a luxurious feel and enhanced protection. Poly microfiber car covers are highly effective in shielding vehicles from UV rays, dust, dirt, and light rain. The microfiber material also provides excellent moisture absorption, preventing condensation and reducing the risk of mold and mildew. Additionally, poly microfiber car covers are lightweight, making them easy to handle and install. With their combination of durability, softness, and advanced protection, poly microfiber car covers offer a premium solution for keeping vehicles pristine and well-protected.

An imitation stain car cover is a cost-effective alternative to genuine stain car covers. Designed to mimic the appearance and texture of genuine stain materials, these covers offer a similar aesthetic appeal at a more affordable price point. Typically constructed from synthetic fabrics like polyester or nylon, imitation stain car covers provide reliable protection against UV rays, dust, dirt, and light rain. While they may not possess the same level of durability or authenticity as genuine stain car covers, they still offer decent resistance to tears and abrasions. Imitation stain car covers are lightweight and easy to handle, making installation and removal a breeze. They come in various sizes and styles to fit different vehicle types, ensuring a snug and secure fit. For car owners looking for a budget-friendly option that offers some level of stain-like aesthetics and protection, an imitation stain car cover can be a suitable choice.

A plastic car cover is a simple and affordable solution for temporarily protecting a vehicle from the elements. Made from durable plastic materials such as polyethylene or PVC, these covers are lightweight and easy to handle. Plastic car covers offer basic protection against dust, dirt, and light rain, keeping the car's exterior relatively clean. They are typically transparent or semi-transparent, allowing for visibility of the vehicle underneath. Plastic car covers are quick to install and remove, making them convenient for short-term use, such as during car storage or when parked outdoors temporarily. While they may not provide the same level of protection as fabric-based covers, plastic car covers serve as a cost-effective option for keeping a vehicle shielded from minor environmental factors.

A parachute cover is a specialized type of car cover that offers exceptional protection against harsh weather conditions. Inspired by the strength and durability of parachute materials, these covers are typically constructed from high-quality nylon or polyester fabrics. Parachute covers are designed to be highly resistant to UV rays, rain, snow, and other elements that could potentially damage a vehicle's exterior. They feature reinforced stitching and secure fastening mechanisms to ensure a snug fit and prevent wind from lifting or damaging the cover. Parachute covers are often breathable, allowing moisture and condensation to escape, reducing the risk of mold and mildew. With their robust construction and reliable performance, parachute covers provide reliable protection for vehicles in extreme weather conditions, making them an ideal choice for outdoor storage or long-term protection.

So, in our project, we used parachute cover that's is economically better than others ones. There are some properties of this cover are:

- Affordable
- Lightweight
- Water-Resistant
- Less expensive

It is available in Pakistan and its price range from 1300 to 2000 (PKR).

4.2 Hardware of Automatic Car Cover

For retractable mechanism, we used different components to fabricate the project there prices and quantity show in the table 4.2.

Table 4.2 List of Hardware Components

List of Components	Materials	Quantity	Price (PKR)
Frame	Iron	03	10,000
Scissor	Galvanized Iron	36	10,000
Bearing	Collar Bearing	96	9,600
Motors	Stepper Motors	04	4000
Wheels	Caster Wheels	04	6000
Rods	T-8 Rods	04	1000
Linear Guides	Steel / Aluminum	04	32,000

The hardware of a retractable car cover consists of a lightweight and sturdy framework typically made of iron. Some features may include scissor mechanisms, handles, and control buttons for easy operation. The hardware is designed to provide stability, longevity, and ease of use, ensuring the functionality and effectiveness of the retractable car cover. The T-8 rods is attached with motor due to which the system will become automated.

4.3 Iron Pipes for Frame

The retractable car frame utilizes 17.5 mm iron pipes for its construction. These lightweight yet sturdy pipes are specifically chosen for their strength and durability. The 17.5 mm diameter provides a balance between structural stability and weight reduction, making them ideal for supporting the retractable car cover. The iron material offers resistance against corrosion, ensuring longevity even in different weather conditions. The precise measurements and quality craftsmanship of the 17.5 mm iron pipes contribute to the overall stability and smooth operation of the retractable car frame. We will have used 3 frames for the contraction and expansion of retractable frame. So, the stability of system will enhance. As the one frame is fixed while others frame will be retractable and follow through scissor structural mechanism the drawing of the frame is show in figure 4.1.

4.4 Galvanizes Iron Bars in Scissor Structural Mechanism

The retractable mechanism of the car cover incorporates 300 mm galvanized iron bars to ensure strength and durability. These bars, measuring 300 mm in length, provide crucial support and stability to the retractable mechanism. The galvanized iron material is chosen for its resistance to corrosion, protecting the bars from rust and ensuring their longevity. The precise measurements and quality construction of the 300 mm galvanized iron bars contribute to the smooth operation of the retractable mechanism, allowing for effortless extension and retraction of the car cover. The sturdy nature of these bars enhances the overall reliability and functionality of the retractable mechanism, ensuring years of dependable use. For the construction of retractable frame, we used 32 scissor bars which made four pairs. So, one pairs consist of 8 bars and gives almost expansion length is about 200(mm). So, the bars will be automatic through motors which can open or close the mechanisms by pushing just button. The bars shaped is U type which will not bend during the running mechanism as show in the figure 4.2.

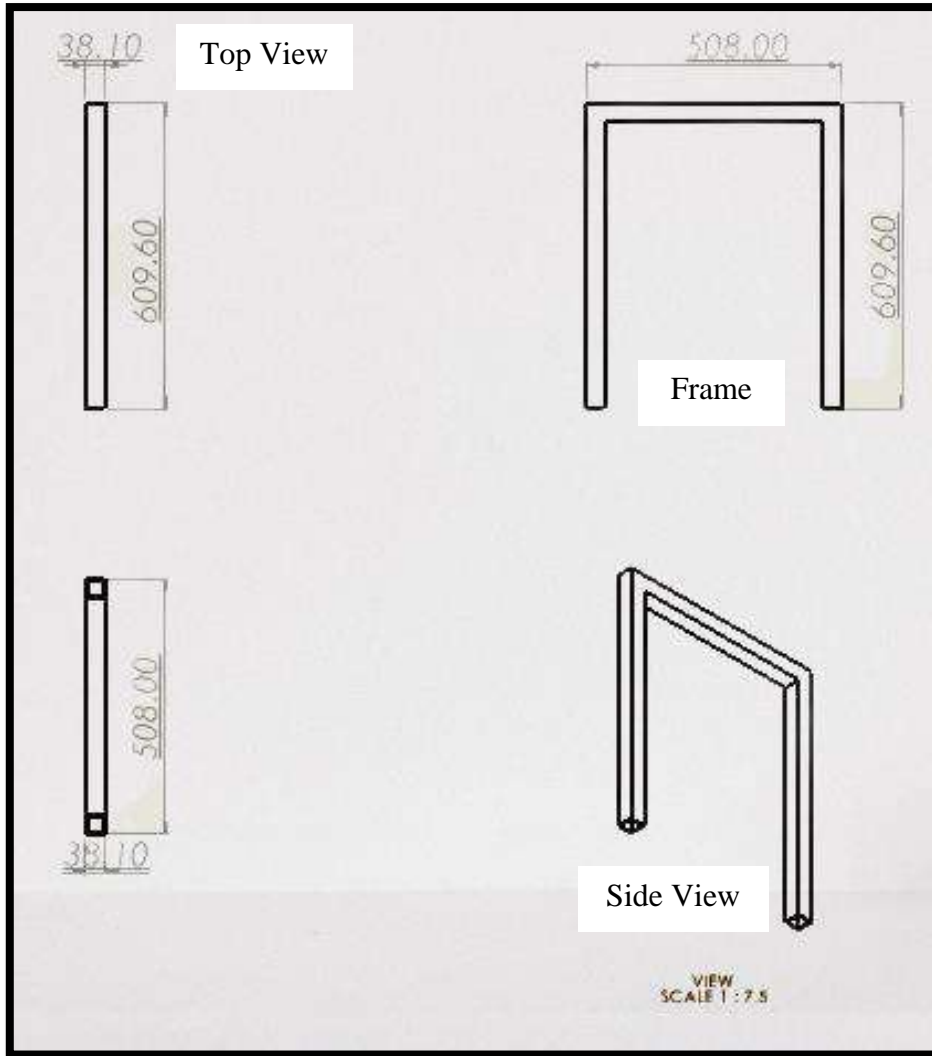


Figure 4.1: Model of Frame

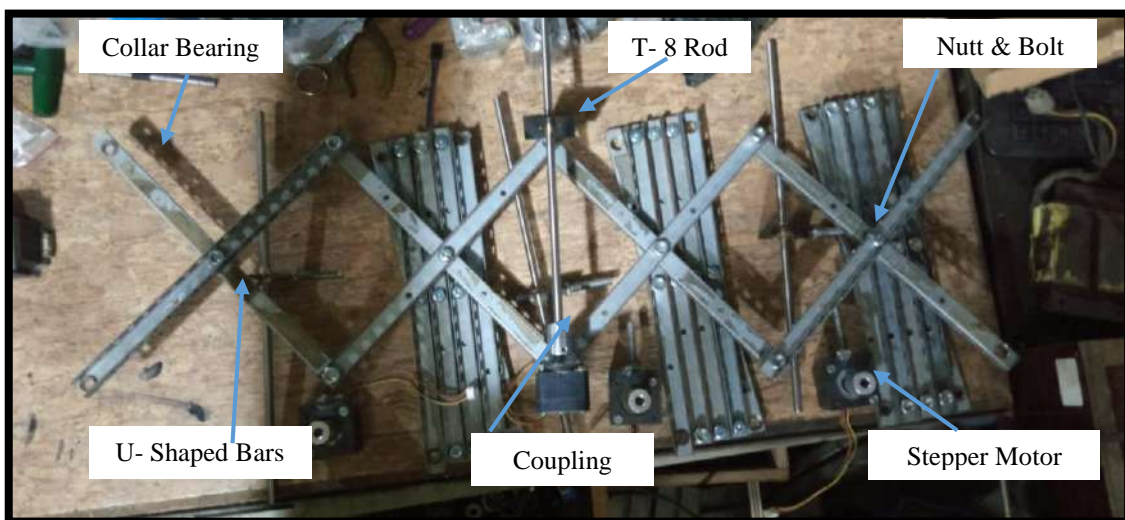


Figure 4.2: Mechanism of Double Scissor Bars for Retractable cover

4.5 Collar Bearing for Movement of Bars

The retractable scissor mechanism of the car cover incorporates collar bearings with an inner diameter (ID) of 8mm and an outer diameter (OD) of 12mm. These bearings play a critical role in facilitating smooth movement and reducing friction within the scissor mechanism. The 8mm ID ensures a precise fit onto the corresponding bars, while the 12mm OD provides stability and support within the mechanism. The collar bearings are designed to withstand the load and stress exerted during the extension and retraction of the scissor mechanism. For the scissor mechanism, we used 96 collar bearings for the movement of the bars. Besides bearings, during the closing and opening of bars, there will be friction. So, to eliminate the friction, we used 3 collars bearing for one bar. There is total 96 bearings used for 32 bars.

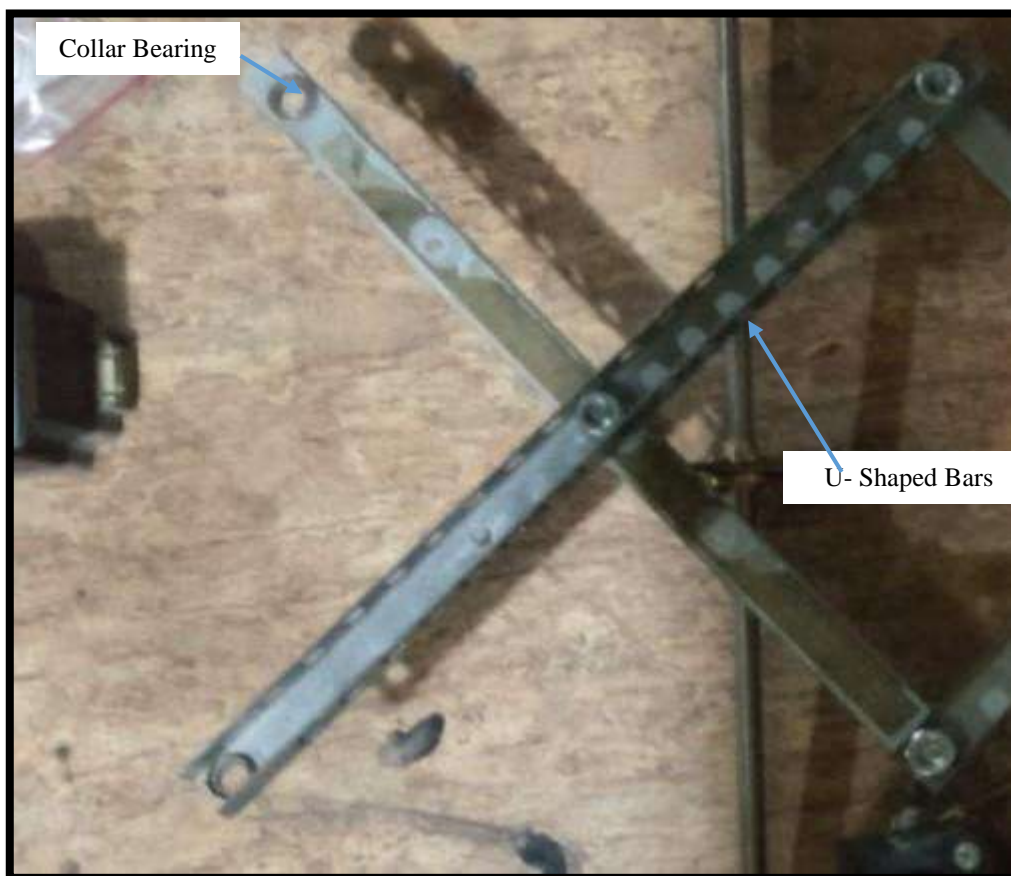


Figure 4.3: Collar Bearing for joint of Bars

4.6 Stepper Motor for Opening & Closing of Frame

The closing and opening mechanism of the retractable car cover is powered by a stepper motor. Stepper motors are commonly used for their precision and control in various applications. In this case, the stepper motor is specifically chosen for its ability to provide accurate and controlled movements during the operation of the retractable car cover. It enables smooth and precise positioning of the cover, ensuring proper alignment and secure closure. The stepper motor works by converting electrical pulses into precise mechanical rotations. It operates in

discrete steps, allowing for precise control over the movement of the car cover. The motor's step angle determines the degree of rotation per step, ensuring accurate positioning of the cover during the opening and closing process. This level of control allows for precise adjustment and customization of the opening and closing speed of the car cover. Furthermore, the stepper motor offers good holding torque, ensuring that the cover remains securely closed or opened in place, even in windy conditions. It is also known for its reliability and durability, making it suitable for regular use in the retractable car cover mechanism. We used 4 stepper motors for opening and closing the mechanism. As one motor is attached with one pair (which consist of 4 cross bars). Similarly, 4 motors attached with four pairs. These motors smoothly close or open the scissor mechanism. The specifications of stepper motor are;



Figure 4.4: Stepper Motor for Movement of Frame

Overall, the stepper motor plays a crucial role in the smooth and controlled operation of the retractable car cover, providing accurate movements, secure closure, and reliable performance.

4.6 Caster wheel

Caster wheels are commonly used in retractable car covers to enhance mobility and ease of movement. These wheels are typically attached to the bottom frame of the cover, allowing for smooth and effortless maneuverability when extending or retracting the cover. Caster wheels are chosen for their ability to rotate 360 degrees, providing multidirectional movement. This enables users to easily guide the car cover in any desired direction, whether it's forward, backward, or sideways. The wheels are designed to roll smoothly on various surfaces, including concrete, asphalt, or other flooring materials, ensuring minimal effort is required to move the cover. The caster wheels used in retractable car covers are often made of durable materials such as rubber or polyurethane. These materials offer excellent traction and shock absorption, allowing for smooth and stable movement without causing damage to the underlying surface. There is total 3 frames, so according to these 3 pair of caster wheel are used in our project.

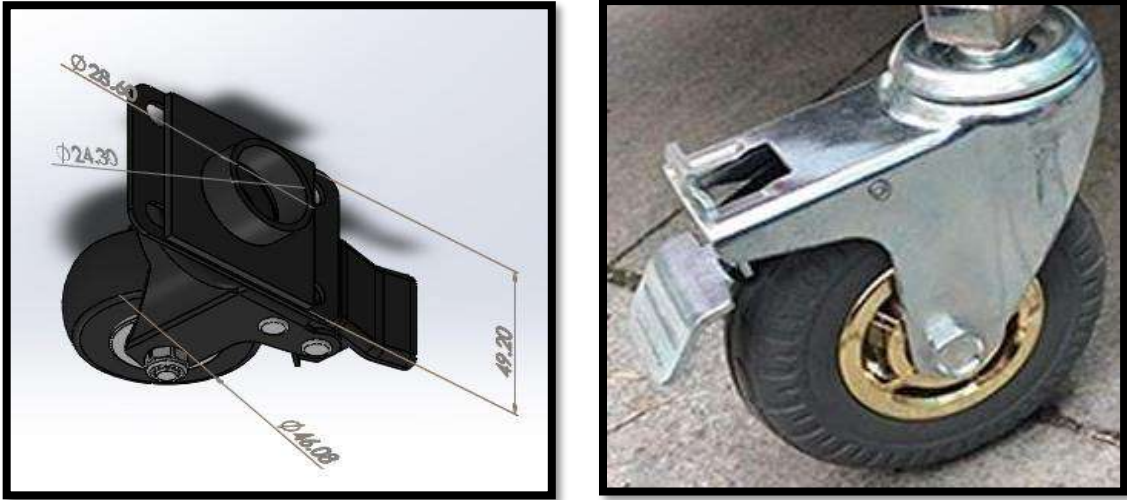


Figure 4.5: Caster Wheel for Ease Movement of Frame

4.7 T-8 Rods for Linear Motion of Frame

T-8 rods are key components used in stepper motors for retractable car covers. These rods, also known as lead screws, play a crucial role in converting the rotational motion of the stepper motor into linear motion. The T-8 designation refers to the thread type and pitch of the rod, indicating the distance the rod advances per revolution. Made of durable materials like stainless steel or hardened steel, the T-8 rods are precisely machined for smooth operation and reliable performance. As the stepper motor rotates, the T-8 rods translate this rotational motion into linear motion, enabling the extension and retraction of the car cover. The accurate threading and pitch of the T-8 rods ensure precise and controlled movement, ensuring proper alignment and secure closure of the car cover. With their contribution to the stepper motor mechanism, the T-8 rods play a crucial role in the smooth and efficient operation of retractable car covers. There are used four motors for scissor structural mechanism. So, 4 T – 8 rods are used which convert the rotational motion into linear motion. The pitch of T -8 rod is 2 mm and lead are also 2 mm.

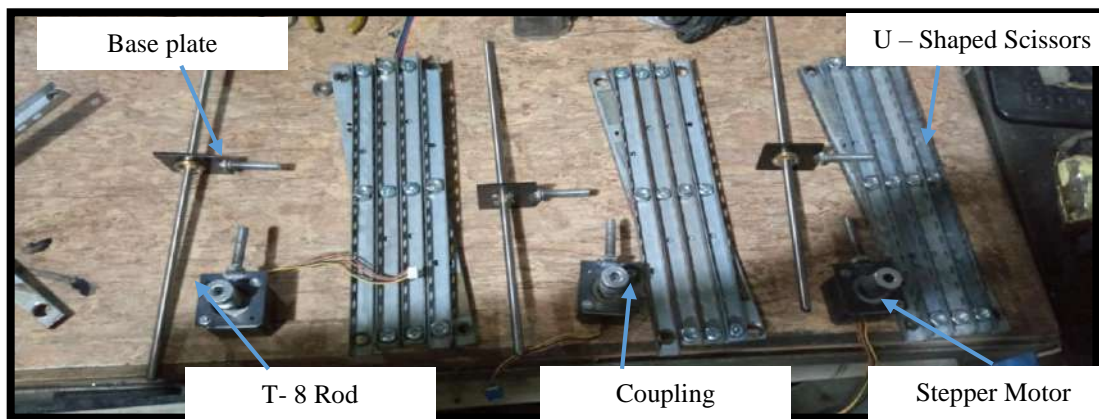


Figure 4.6: T-8 Rod for Rotational to Linear Motion

4.8 Linear Guides

Linear guides are essential components used in retractable car covers to facilitate smooth and precise linear motion. These guides, also known as linear slides or linear bearings, ensure stability and accuracy during the extension and retraction of the car cover. Typically made of high-quality materials such as steel or aluminum, linear guides are designed to withstand heavy loads and provide reliable support. The linear guides consist of a rail and a carriage. The rail is a long, straight track that serves as a guide for the carriage. The carriage, attached to the car cover mechanism, moves along the rail in a linear fashion. By incorporating linear guides into retractable car covers, the extension and retraction process is enhanced with improved stability, reduced vibrations, and minimized wear. The linear guides ensure accurate alignment and prevent misalignment or wobbling of the car cover. This results in a secure and tight fit, providing optimal protection for the vehicle. Their smooth operation and reliable performance make them an integral part of the mechanism, ensuring seamless and efficient functionality of the retractable car cover system. We used 04 linear guides for the stability of the frame.



Figure 4.7: Linear Guide for Alignment

CHAPTER FIVE: DISCUSSION AND RESULTS

In this chapter, we discussed the results of mechanism and perform testing on the retractable car cover. As the retractable car cover consist of three frames. The total length of frame is 1000 (mm) which is the maximum opening of frame. The minimum length of frame when retract is 200 (mm). similarly, the height of frame is 610 (mm) and width is 450 (mm). With the push of a button or a simple manual operation, the cover can be extended or retracted within seconds. This convenience is particularly valuable in situations where quick protection is required, such as sudden rain showers or intense sunlight. Retractable car covers also offer versatility in terms of coverage. They can fully enclose the vehicle, providing protection not only from rain and sunlight but also from dust, bird droppings, and other environmental contaminants. The opening time of fully expansion of mechanism is round 30 sec. similarly, the mechanism close around 20 sec.

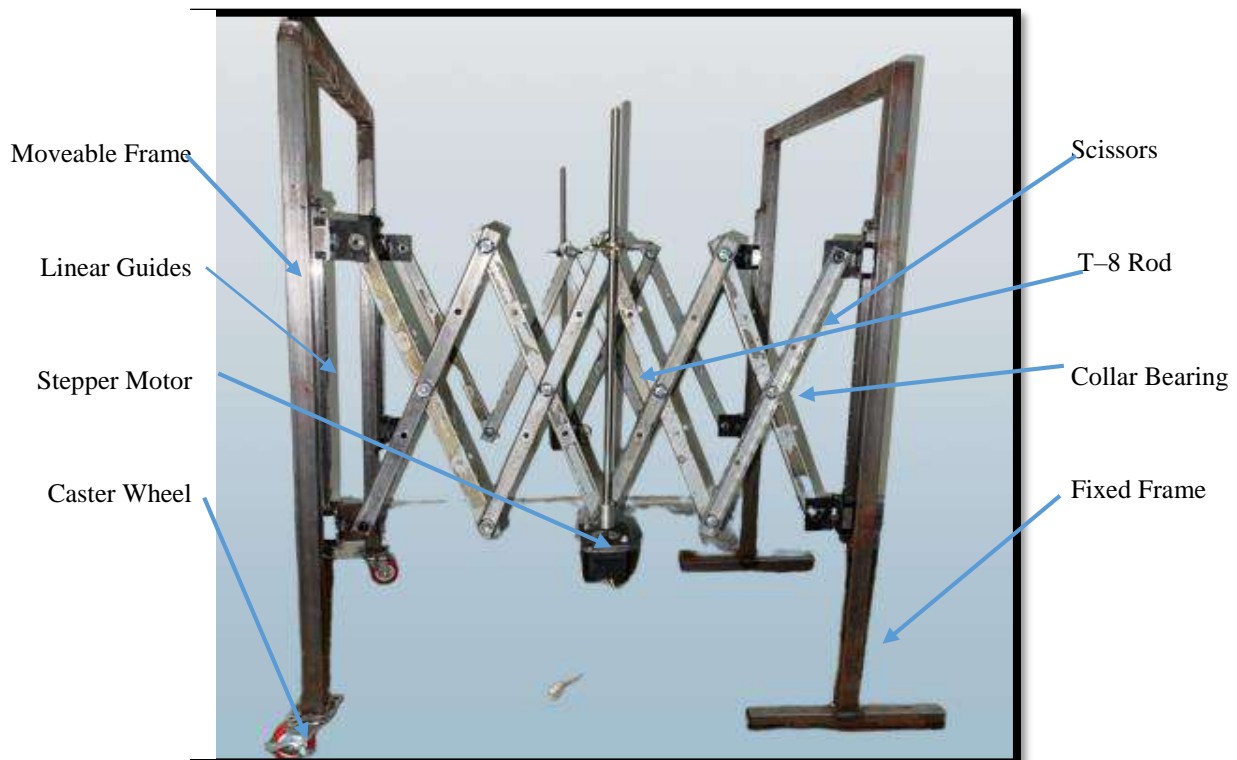


Figure 5.1: Prototype Retractable car cover Mechanism

5.1 Opening and Closing time of Mechanism

There are four stepper motor with a current rating of 17 A and a torque of 180 g-cm (gram-centimeter) can provide significant power and torque for operating a retractable car cover. However, it's important to note that the suitability of this motor for a specific retractable car cover application depends on various factors, including the size and weight of the cover, the desired speed of operation, and the mechanical design of the system. The speed at which the retractable car cover operates depends on the motor's step resolution and the control system used. The speed of a retractable car cover is typically determined by the rotational speed of the

motor used in the system. Stepper motors, commonly employed in these applications, move in discrete steps, and the speed is determined by the number of steps taken per second. The motor's torque output and power rating also influence the speed at which the cover can be opened or closed, as higher torque motors can overcome resistance and move the cover faster. With a higher current rating, the motor can potentially achieve faster step rates, enabling quicker operation of the car cover. The total weight of retractable car mechanism is 5 kg. So according to size and weight, there are four motor which open or close the frame. The 17 A current rating indicates that the motor can handle a relatively high current flow, which corresponds to increased power output. This higher power can assist in driving the cover mechanism efficiently and overcoming resistance from elements such as wind or friction.

The speed at which a retractable scissor mechanism operates in opening or closing a car cover can vary depending on various factors, including the design of the scissor mechanism, the power source, and the control system employed

- **Mechanism Design:** The design of the retractable scissor mechanism itself can affect the speed of operation. The length and arrangement of the scissor arms, as well as the pivot points, determine the range of motion and the speed at which the system can extend or retract.
- **Power Source:** The type and power of the motor or actuator used to drive the scissor mechanism can influence the speed of operation. Different types of motors or actuators, such as electric motors or hydraulic/pneumatic systems, have varying speed capabilities. The power output, torque, and speed ratings of the motor or actuator should be compatible with the requirements of the retractable scissor mechanism.
- **Control System:** The control system plays a crucial role in regulating the speed of the retractable scissor mechanism. The control algorithms and programming can adjust the power or voltage supplied to the motor or actuator, controlling the speed of operation. Acceleration and deceleration profiles may also be implemented to ensure smooth and controlled movement.



Figure 5.2: Opening & closing of car cover

- **Load and Weight:** The weight of the car cover itself, along with any additional factors such as wind resistance, can impact the speed at which the retractable scissor mechanism operates. Heavier loads may require more power and potentially result in slower operation to ensure safe and reliable movement.

5.2 Vibration in Scissor Structural Mechanism

Vibration in a scissor structural mechanism can be generated due to several factors and can have various causes and effects. Here are some common factors that can contribute to vibration in a scissor structural mechanism.

5.2.1 Causes of Vibration

- **Dynamic Loads:** During operation, scissor mechanisms are subjected to dynamic loads such as acceleration, deceleration, or changes in direction. These dynamic forces cause the scissor mechanism to vibrate, especially if they are not adequately controlled or balanced.
- **Mechanical Stiffness:** The stiffness of the scissor mechanism's components and the connections between them will influence its vibration characteristics. If the structure lacks sufficient stiffness, it may experience excessive flexing or deformation, leading to vibrations.
- **Resonance:** Scissor mechanisms have natural frequencies at which they tend to vibrate more easily. If external forces or operational conditions match the natural frequency of the scissor mechanism, resonance may occur, resulting in amplified vibrations.
- **Imbalance:** Imbalance in the distribution of loads or weight within the scissor mechanism causes vibrations. For example, if one side of the scissor structure is significantly heavier than the other, it can create an imbalance that leads to vibrations during operation.
- **Wear and Misalignment:** Over time, wear, tear, and misalignment of the scissor mechanism's components can contribute to vibrations. As components become loose or misaligned, it can introduce unwanted movement and vibration during operation.

5.3 Effects of Vibration in Mechanism

- **Reduced Stability and Precision:** Excessive vibrations compromise the stability and precision of the scissor mechanism.
- **Increased Wear and Fatigue:** Vibrations can accelerate wear and fatigue of the scissor mechanism's components, leading to premature degradation, increased maintenance requirements, and potential mechanical failures.
- **Noise and Discomfort:** Vibrations often result in the generation of noise, which can be undesirable in certain applications. Additionally, excessive vibrations can cause discomfort to users or occupants of the structure.

5.4 Mitigating Vibration in Mechanism

- **Damping and Isolation:** Incorporate damping elements or techniques to absorb and dissipate vibrations. This can include the use of vibration isolation mounts, damping materials, or shock absorbers at critical points within the scissor mechanism.
- **Regular Maintenance:** Implement a maintenance schedule to inspect and address any wear, misalignment, or loose components in the scissor mechanism. Regular lubrication and tightening of connections can help minimize vibrations caused by these factors.
- **Material Selection:** Choose materials with appropriate stiffness and damping properties for the scissor mechanism. Consider materials that can withstand the anticipated loads and reduce vibrations.
- **Bearings to reduce Friction:** Bearings are used to reduce friction. They provide smooth movement between two mating points.

It's important to note that the specific approach to mitigate vibrations in a scissor structural mechanism will depend on the particular design, application, and operating conditions.

5.5 Testing of Mechanism

By conducting the testing of mechanism, there are faced some issues while opening the mechanism. The alignment of mechanism is not correct due to friction and vibration in the mechanism. The contraction of mechanism is not achieved required length due to misalignment of linear guides. Misalignment of the scissor mechanism in a retractable car cover can have significant consequences on its functionality and overall performance. Misalignment refers to a condition where the components of the scissor mechanism are not properly aligned or positioned, causing them to deviate from their intended positions. Several factors can contribute to misalignment, such as wear and tear over time, improper installation, damage or impact, or loosening of fasteners. The effects of misalignment can be problematic. The misalignment can cause excessive friction and strain on certain components, leading to accelerated wear and potentially causing component failures. Operational issues like jamming, sticking, or binding may arise, making it difficult to smoothly open or close the cover. Additionally, misalignment can generate noise and vibrations during operation, causing discomfort and annoyance. Regular inspection and maintenance, proper installation techniques, tightening and alignment checks, and appropriate lubrication can help address misalignment issue.

5.6 Effect of U- Shaped Bars

The use of U-shaped bars in a scissor structural mechanism offers several benefits compared to normal straight bars. Here are some advantages of utilizing U-shaped bars:

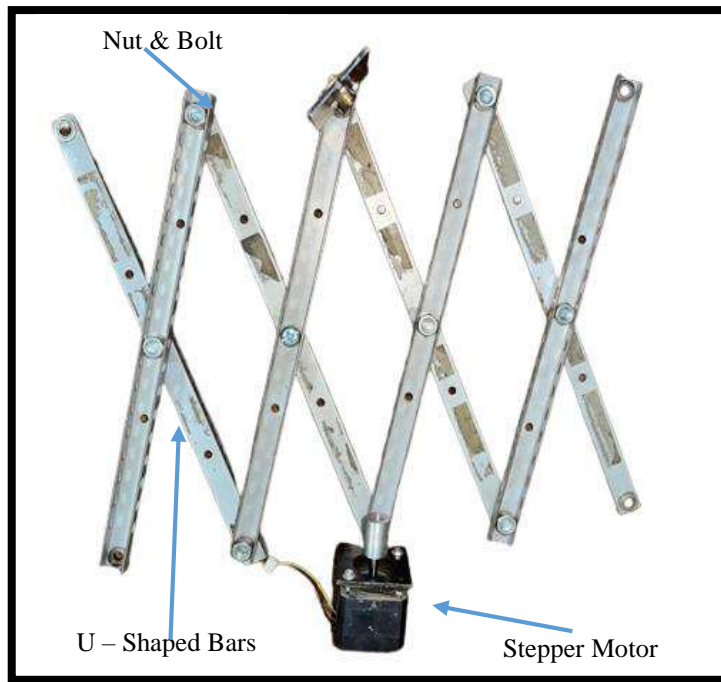


Figure 5.3: U – Shaped Bar for Reduction of Vibration

- **Increased Structural Strength:** The U-shaped design provides improved structural strength compared to straight bars of the same material and dimensions. The curved shape of the U-bars distributes forces more evenly along the length of the bars, reducing stress concentrations and enhancing overall structural integrity.
- **Enhanced Stiffness:** The U-shaped bars offer higher stiffness compared to straight bars, allowing for better resistance against bending and torsional forces. This increased stiffness minimizes deflections and deformations during operation, ensuring more stable and precise motion of the scissor mechanism.
- **Improved Load Distribution:** The U-shaped bars distribute loads more efficiently compared to straight bars. The curvature of the U-bars helps to evenly distribute applied forces, reducing concentrated stress points. This results in a more uniform load distribution among the scissor mechanism components, leading to enhanced load-carrying capacity and reduced risk of localized failures or deformations.
- **Enhanced Compactness and Space Efficiency:** The U-shaped bars allow for a more compact and space-efficient design compared to straight bars. The curved shape enables the bars to fold and stack tightly together when in the closed position, minimizing the space required for storage or transportation.

5.7 Literature Data

In literature data, there is an umbrella car cover which is not convenient in all aspects. This type of car cover resembles a large umbrella, with a collapsible frame and a cover that stretches over the car's exterior. While umbrella car covers offer temporary protection for parked vehicles, it's important to note that they may not provide the same level of coverage and security as permanent or fully enclosed car covers. They are best suited for short-term use, such as

during outdoor events, vacations, or when parking the car for a brief period. Umbrella car covers provide only temporary and partial protection for parked vehicles. They primarily shield the car's exterior from dust, bird droppings, and light rain. However, they may not provide comprehensive coverage against heavy rain, hail, or extreme weather conditions. In areas with strong winds, the cover may not be as secure and could potentially blow off or become dislodged. In some cases, the fit may be less than ideal, leaving certain areas of the car exposed. An umbrella car cover typically requires a moderate amount of space for installation and storage. Here's a breakdown of the space considerations associated with using an umbrella car cover:

- **Installation Space:** When setting up an umbrella car cover, we need sufficient space around the vehicle to unfold and position the cover properly. This generally requires an area slightly larger than the car's dimensions to accommodate the expanded size of the cover.
- **Parking Space:** Umbrella car covers are designed for use in outdoor parking spaces. We will need a parking area that can accommodate the size of your car and leave additional space for the extended coverage provided by the umbrella cover.
- **Storage Space:** When not in use, an umbrella car cover can be folded and stored in the trunk or storage compartment of your car. The folded cover usually takes up a compact space, comparable to a large umbrella or a folded beach chair.

Overall, while an umbrella car cover requires a significant amount of space, it's important to consider the necessary room for installation, parking, and storage.

5.8 Benefits of Retractable Car Cover

By considering these requirements, a retractable car cover that meets their specific needs and provides the desired level of protection and convenience for their vehicles.

- **Protection:** The primary requirement of a retractable car cover is to provide effective protection for the vehicle. The cover shields the car from various elements such as rain, snow, sunlight, dust, bird droppings, and environmental contaminants. It is made of durable and weather-resistant materials to ensure long-lasting protection.
- **Ease of Use:** A retractable car cover is user-friendly and easy to operate. It has a simple and intuitive mechanism for extension and retraction, allowing users to quickly and effortlessly cover or uncover their vehicles. Automated controls or remote operation can enhance convenience and ease of use.
- **Size and Fit:** The retractable car covers to be designed to fit different vehicle sizes and shapes. It provided a secure fit, covering the entire surface of the vehicle effectively. Adjustable features or customizable options can ensure compatibility with a wide range of vehicles.
- **Durability:** A high-quality retractable car cover built to withstand daily use and harsh weather conditions. Reinforced stitching, robust frame materials, and weatherproof coatings contribute to the overall durability of the cover.

- **Portability and Storage:** The retractable car cover is a lightweight and easily portable, allowing users to transport and store it conveniently. It should be compact when retracted, occupying minimal space in the vehicle or storage area.
- **Maintenance and Cleaning:** The retractable car cover is easy to clean and maintain. It will be resistant to stains and easy to wipe down or machine wash. Quick-drying materials can expedite the cleaning process.

CHAPTER SIX: CONCLUSION AND FUTURE DIRECTION

The objective of the project was to develop a retractable cover mechanism that would effectively protect automobiles from dirt and debris while providing flexibility in adjusting its length. For the fabrication of retractable car cover (Prototype), we have used three frames. One frame is fixed, while others two frame are moveable. The dimensions of these three frames are 1000 (mm) length at maximum position, 200 (mm) at contract position, 610 (mm) height and 450 (mm) width. In scissors, each bar is 300 (mm) long. So, one pairs consist of 8 bars and gives almost expansion length is about 200(mm). The total weight of retractable car mechanism is 5 kg. So according to size and weight, there are four motor which open or close the frame. The 17 A current rating indicates that the motor can handle a relatively high current flow, which corresponds to increased power output. The project successfully implemented a double scissor bar mechanism, utilizing a T8 rod and motor to control the linear motion. Additionally, parachute cover and an adjustable frame were employed to ensure both dirt-proofing and structural strength.

The total cost of this project is 70 thousand (PKR). There are 36 bars used and their cost is 10,000 PKR. Total 96 Collar bearings used and their price is 10,000 PKR. We used four stepper motor for movement of frame. Each stepper motor is 1000 PKR. Similarly, we used 4 linear guides and their price is 32,000 PKR. In this way, the total expenses of this project cross 70 thousand (PKR).

The efficiency of retractable car cover based on its automation which is easy to open or close the cover by just pushing the button in worst weather condition. Its provide protection from sun light, dust and dirt. Unlike traditional car covers, which require manual installation and removal, a retractable cover can be easily deployed or retracted with the push of a button or a simple mechanism. This convenience encourages regular use, ensuring that your car stays protected even during short periods of parking. An efficient retractable car cover should be easy to maintain. Removable and washable covers can be convenient, as they allow you to keep the cover clean and in good condition. The parachute cover is High-quality, durable materials which are water resistant, dirt resistant will provide better protection and last longer. The opening time of fully expansion of mechanism is round 30 sec. similarly, the mechanism close around 20 sec.

The final version of the retractable cover demonstrated satisfactory performance in terms of dirt-proofing, retract ability, and durability. The double scissor bar mechanism proved to be an effective solution for achieving the desired retractable feature. It provided smooth and controlled linear motion, allowing the cover to extend or retract to accommodate different vehicle sizes. The use of parachute cover ensured the cover's dirt-proofing capability. By utilizing the double scissor bar mechanism, the cover can extend or retract according to the user's requirements, ensuring optimal coverage for various vehicle sizes. However, the project also identifies potential areas for future development and improvement.

6.1 Future Directions

While this project has achieved its primary objectives, there are several avenues for future development and improvement. The following directions are recommended for further exploration.

- ❖ Automated Sensors and Controls.
- ❖ Lightweight and Space-Efficient Design

6.2 Automated Sensor and Control

Automated sensors and controls play a crucial role in enhancing the functionality and convenience of retractable car covers. These systems utilize various sensors and control mechanisms to automate the operation of the cover and provide additional features and benefits. Here are some examples of how automated sensors and controls are used in retractable car covers:

- **Proximity Sensors:** Proximity sensors are used to detect the presence of the vehicle or objects in the vicinity of the cover. These sensors ensure that the cover does not close if there is an obstruction, preventing potential damage to the vehicle or surrounding objects.
- **Rain Sensors:** Rain sensors can detect precipitation and automatically trigger the closing of the car cover to protect the vehicle from water damage. These sensors provide an added layer of convenience by eliminating the need for manual intervention during sudden rain showers.
- **Wind Sensors:** Wind sensors are designed to detect strong gusts of wind. When high winds are detected, the control system can automatically retract or secure the cover to prevent damage caused by wind-induced vibrations or lifting.
- **Light Sensors:** Light sensors are used to detect ambient lighting conditions. They can activate the opening or closing of the car cover based on the lighting conditions, allowing for automatic operation depending on the user's preferences or environmental factors.
- **Remote Control:** Many retractable cars cover incorporate remote control functionality, enabling users to open or close the cover remotely with the press of a button. Remote controls offer convenience and ease of use, allowing users to operate the cover from a distance.
- **Timer Controls:** Timer controls allow users to schedule the opening or closing of the car cover at specific times. This feature is beneficial for users who want to automate the cover's operation according to their daily routines or specific time requirements.

These automated sensors and controls enhance the usability and functionality of retractable car covers, providing convenience, protection, and peace of mind for vehicle owners. They ensure efficient and automated operation while offering additional features to adapt to different weather conditions and user preferences.

6.3 Lightweight and Space efficient

A lightweight and space-efficient design is essential for retractable car covers to ensure ease of use, portability, and efficient storage. Here are some key aspects of a lightweight and space-efficient design in retractable car covers:

- **Material Selection:** Choosing durable materials is crucial for reducing the overall weight of the cover. Common materials used include lightweight aluminum or composite materials for the frame and lightweight, weather-resistant fabrics for the cover itself. These materials offer a good balance between strength, durability, and weight reduction.
- **Compact Folding Mechanism:** An efficient folding mechanism allows the retractable car cover to be compactly folded when not in use. This design feature ensures that the cover takes up minimal space during storage or transportation. It allows users to easily store the cover in the trunk or other confined spaces without sacrificing valuable space.
- **Modular Construction:** A modular design approach enables easy disassembly and reassembly of the retractable car cover. This allows for more convenient storage, as the cover can be broken down into smaller, stackable components. Users can easily assemble the cover when needed and disassemble it for compact storage when not in use.
- **Retraction System:** An efficient retraction system is important for compactness and ease of use. The retractable car cover should have a smooth and reliable mechanism that allows for effortless extension and retraction. This ensures that the cover can be quickly and easily deployed or stored without taking up excessive space or requiring complicated maneuvers.
- **Lightweight Support Structure:** The supporting structure of the retractable car cover should be lightweight yet sturdy. Designing the frame with lightweight materials and optimizing the structure for strength-to-weight ratio helps reduce the overall weight while maintaining the necessary structural integrity.
- **Portable Carrying Case:** Providing a dedicated carrying case or bag for the retractable car cover adds to its portability and convenience. The carrying case should be lightweight and compact, allowing users to transport the cover easily. It should also have proper compartments or storage pockets to accommodate all the components of the cover.

By incorporating a lightweight and space-efficient design, retractable car covers offer benefits such as easy handling, portability, and efficient storage. These features make them suitable for frequent use, outdoor adventures, or situations where space constraints are a concern. Additionally, a well-designed lightweight cover can contribute to fuel efficiency by reducing the additional weight added to the vehicle during transportation.

6.4 Concluding Remarks

The user experience and design of retractable car covers can be significantly enhanced by leveraging customer feedback. By actively seeking and analyzing customer input, manufacturers can make informed design decisions that align with customer needs and preferences. Improvements based on customer feedback can encompass usability, functionality, aesthetics, ergonomics, and convenience. Employing an iterative design process

that involves continuous customer engagement ensures that retractable car covers are refined to meet the evolving demands of the market, resulting in higher customer satisfaction and product success.

The project has successfully developed a prototype of retractable cover mechanism for dirt proofing of automobiles. The future direction lies in reducing production costs, incorporating self-alignment features through sensor integration, exploring advanced materials, and enhancing the overall user experience. These endeavors will contribute to creating a more affordable, efficient, and user-friendly solution for protecting automobiles from dirt and debris, ultimately benefiting a wide range of automobile owners.

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