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Design of Motorised Handicaps Wheelchair

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Abstract

First wheelchair model advanced lengthy again in 18th century, but speedy development on this field initiated considering the fact that mid of twentieth century. Seeing that then, many forms of fashions were designed, extending into extensive range of merchandise. This task involves the design of an ergonomically designed electric powered wheelchair for domestic use by using Indian old aged people. Stair hiking functionality is embedded in the layout through its structure and mechanism. The product particularly consists of three modules viz. seat, hyperlinks and body. Anthropometric measures are considered inside the dimensioning of seat. The body and wheels are designed and advanced through the equations generated from the statistical records of dimensions of staircases in Indian houses. Cognizance is laid on extraordinary parameters including shape, capability, generation and architecture of the product. The design is verified by using growing virtual Mockups of man or woman elements are generated in CATIA and are assembled to shape the final product. Necessary simulations of the product are generated in digital surroundings of CATIA. The physical and focused prototype indicating the structure and functionality is evolved the usage of thermocol fabric. Right here wheel vendors are made in RP (Fused Deposition Modeling) the use of ABS (Acrylo Butadiene Styrene) cloth.

INTRODUCTION

A motorized wheelchair or electric powered-powered wheelchair is a wheelchair that is propelled by way of manner of an electric motor in place of manual energy. Motorized wheelchairs are beneficial for the ones who aren't able to impel a manual wheelchair or who may also want to hire a wheelchair for distances or over terrain which might be strenuous in a guide wheelchair. They will additionally be used no longer simply with the aid of human beings with traditional mobility impairments, however additionally by way of human beings with cardiovascular and fatigue based totally conditions. electric wheelchairs have superior the great of lifestyles for lots humans with bodily disabilities via the mobility they manage to pay for. The selection of strength chair will depend on many factors; which include the kind of surface setting the chair might be driven over, the need to settle thresholds and curbs, and clearance widths in accustomed environment. The maximum essential process of the chair is to take input from the person, typically within the form of a small joystick, and decipher that motion into power to the wheels to transport the person in the preferred path. The previous couple of years have seen plentiful enhancements and fashions that give the user unrivaled manage of the wheelchair in terms of user effort and vehicle aptitude.

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Problem Statement

A stair climbing powered wheelchair designed for elderly people at domestic places.

Objective of Work

The goal of this challenge is to analyze and prototype a motorized wheelchair primarily based on sizeable truth findings and studies on current models, technology used, marketplace state of affairs and patron necessities. The path of our work

starts to consume with the planning section related to initial research, literature overview and historical past look at. It's far accompanied via concept generation phase that consists of evaluating client necessities, outlining specifications and producing concept designs. Next comes the system level layout wherein product architecture is described and elements are modeled in CATIA. The fourth phase is distinct design phase wherein we recognition on layout for assembly and manufacturing and simulation in virtual surroundings. Within the very last phase, we progress towards prototyping and testing a feasible version.

REVIEW LITERATURE

The studies and evaluation of motorized wheelchairs dates again in time with several scientists and researchers evaluating the stair climbing mechanism. Ghani et al [1] investigate the manipulate of a stair mountaineering wheelchair used for indoor functions. This paper evaluates distinctive stair climbing mechanisms viz crawler type, leg kind, hybrid kind and wheeled kind. The model of a stair hiking wheelchair based totally on two wheels is generated the usage of MSC visual Nastran 4D (VN) design software program. The humanoid model is evolved the use of requisite anthropometric facts. Numerous forces and torques acting at the wheelchair at the same time as mountaineering the steps are evaluated. ideally, the outer assist assembly incorporates wheels on either aspect of the chair. An internal assist assembly, closer to the centerline of the chair, additionally supports the seat meeting. Franco et al [2] did work associated with development of a stair mountain climbing wheelchair which could flow in dependent and unstructured environments, hiking over obstacles and going up and down stairs. The wheelchair design is vividly elaborated. The wheelchair consists of a frame, seat and a linkage mechanism connecting the same. The body includes a chassis embedded with motorized locomotion devices, a assist for 2 electric gear-cars, two idle triple wheels gadgets and a battery percent. The seat is a tubular shape that consists of a chair and a pivoting wheel. The linkage mechanism is responsible for relative motion among body and seat all through stair mountaineering operation. To efficaciously climb the stairs, it's miles required to move the seat backwards, then reorient it and in the end elevate up the pivoting wheel. While the seat is moved backwards, the middle of mass of the wheelchair shifts to a safe role, and toppling is accordingly prevented. A four bar linkage is appointed for the same. The linkage mechanism is actuated with the aid of a mini-motor related to a lead screw device. When the seat reaches the preferred function the motor is turned off and no more strength is needed to preserve the placement. The patron requirements had been studied and evaluated after referring them from the DLF (Disabled dwelling foundation) factsheet.

The factsheet aptly outlines what the consumer needs, wheelchair functions, initial considerations before shopping for a wheelchair, wheelchair controls, a way to negotiate curbs, specs of batteries and chargers, special features of motorized wheelchairs, accessories of various types of wheelchairs in addition to approximately coverage and patron requirements. Murray. [3] Has elaborated the historical past as well as latest trends in mobility assistive mechanisms while discussing the relative significance of stairs and wheels. Those various types encompass mobility scooters, song based totally stair climbers, clustered wheel concept and caterpillar wheel based totally devices. A mechanism is proposed which is primarily based on the usage of 4 wheels. The rear wheels are autonomously driven and the front wheels are freewheeling castors. This proposed concept is

numerically modeled and electricity calculations for linear actuator are made. Stair ascent and stair descent operations are defined along with figures and equations. The manage device and the stair side sensor machine also are investigated. The stepping algorithm is discussed in element. The have an effect on of outside factors like price, weight, aesthetics, variety of operation, protection, operational efficiency, consolation are evaluated. The music based stair climber is likewise analyzed in addition. Lockton [4] discusses the unfashionable fitting of electric energy into guide wheelchairs. The existing products and configurations are reviewed in a comparative table. Diverse product specifications are classified and in brief described. Those consist of manage gadgets, drives, guidance and function. diverse configurations viz dual-wheeled force, rear-established, with differential steering, single-wheeled drive, rear-installed, with guidance beforehand of the wheel, single-wheeled pressure, rear-installed, with steerage above the wheel, single-wheeled pressure, rear-established, with nutation steering and single-wheeled drive, the front-installed, with handlebar/articulated guidance are evaluated. The motors, mechanics, manage generation and usability is investigated for the above mentioned combos. Peizer et al [6] have investigated and summarized the evolution of wheelchairs over 5 years. Anthropometric parameters required to be considered for the design of seat ergonomically, a e-book on Indian anthropometric dimensions by using Prof. D.k. Chakraborty is referred. vital measurements and records had been gathered from Indian Anthropometric layout.

METHODOLOGY Market Study

The methodology for this project began with market study of the product under consideration. This involved extensive evaluation of the various types of wheelchairs available in the market and a precise overview of the Indian market scenario.

Electric Wheelchair

The foremost electric wheelchair becomes invented by using George Klein with the purpose to help the wounded squad dies of the arena war II. With time, it has evolved into many designs and forms. The strength chairs contain a number features like reclining, tilting, seat elevation, chin controller, hand controller and plenty of more. A number of the fashions are transportable that is they can be disassembled and carried along while travelling. The electrical wheelchair is often classified into three classes

- The front wheel powered chair: It is a power chair for indoor purposes. This is a four wheel driven chair and is most flexible among the lot.
- The rear wheel powered chair: It is a power chair facilitated for outdoors. Being rear wheeled, they are appropriate for rugged roads.
- Mid wheel powered chair: This electric wheelchair is apposite for indoors but it has sturdy steering functions.

The heavy duty wheelchair

The heavy duty energy wheelchair has been shown in. it's far designed to be used for outdoor motive and can be customized on the premise of man or woman necessities.. It may be used for touring over coarse surfaces. Those energy chairs can be transferred most effective by means of the aid of lifts and ramps.

Heavy duty wheelchair

Transportable wheelchair

This kind of power wheelchair may be without problems conveyed by distinctive feature of its mild weight and thus it is able to be disassembled rapid and trouble unfastened. Due to its compact length, it is apt for slender doorways and halls.

Transportable wheelchair

Powerbase wheelchair

Those energy wheelchairs, proven ordinarily specific due to their better battery array. Being unfold able, it requires lifts all through travel. it's far suitable for both outdoor and indoor journey. This wheelchair guarantees a smooth and strong traverse.

Mobi electric folding wheelchair

This wheelchair is operated like a habitual guide wheelchair. Even as the user pushes on the hand rims, force sensors in the edges understand the consumer's physical effort and adjoin supplementary strength to the wheels. For this reason the bodily movement has similarities to energy guidance in a vehicle. A self-balancing era is integrated that places the consumer inside the centre of gravity whilst balancing on two wheels. The obliteration of the requirement for castor wheels leads to greater condensed and maneuverable medium. The lithium ion batteries which

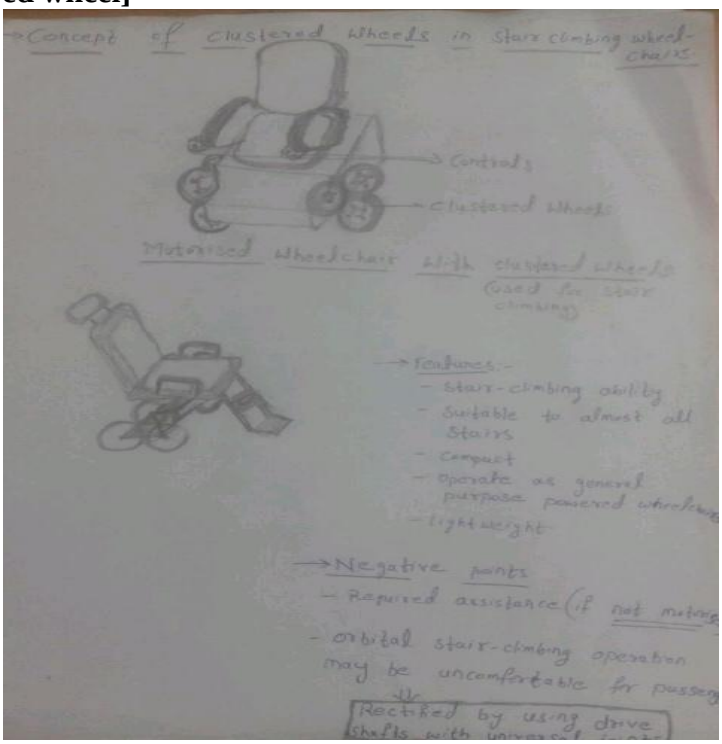
energy the electrical servo automobiles are situated in the base of every of the hub much less wheels and are rechargeable giving the car a range of about 20km with one charge. Wide and ergonomically viable push rims allow an easier grip. One of the models is illustrated.

Foldable wheelchair

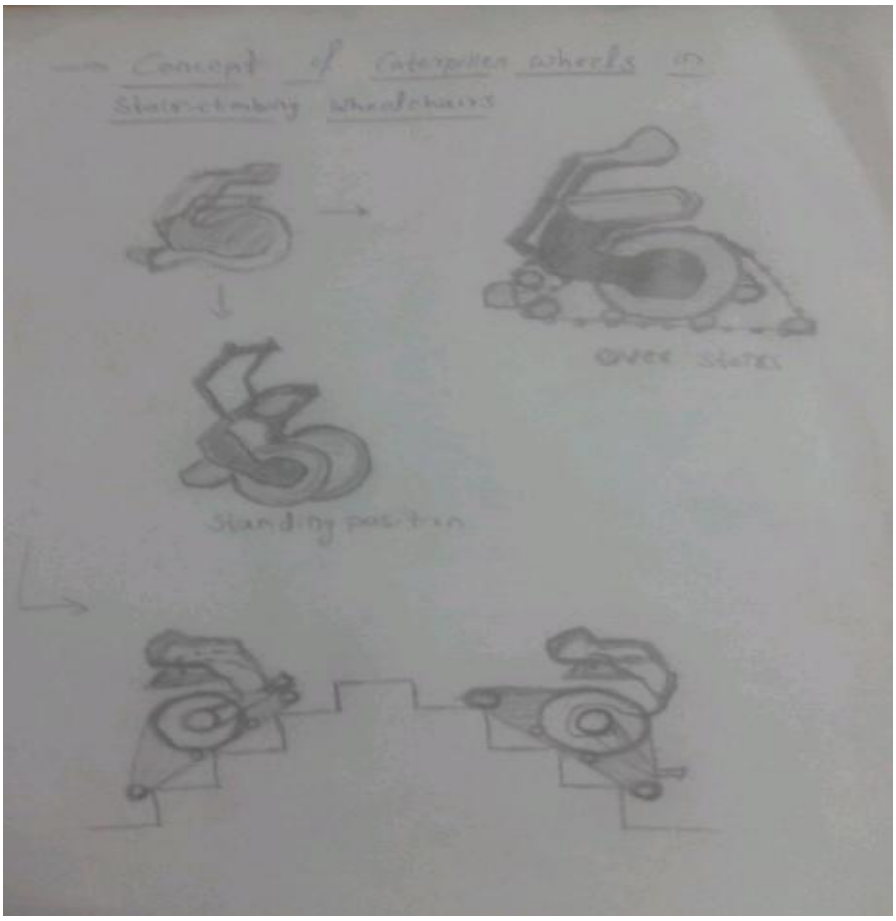
Concept Development

Different mechanisms had been studied and researched upon, depending on specific electricity drives and transmission mechanisms, inclusive of mid-wheel powered, the front wheel powered, music mechanism, clustered wheel concept and caterpillar wheel idea. Following distinct concepts were generated.

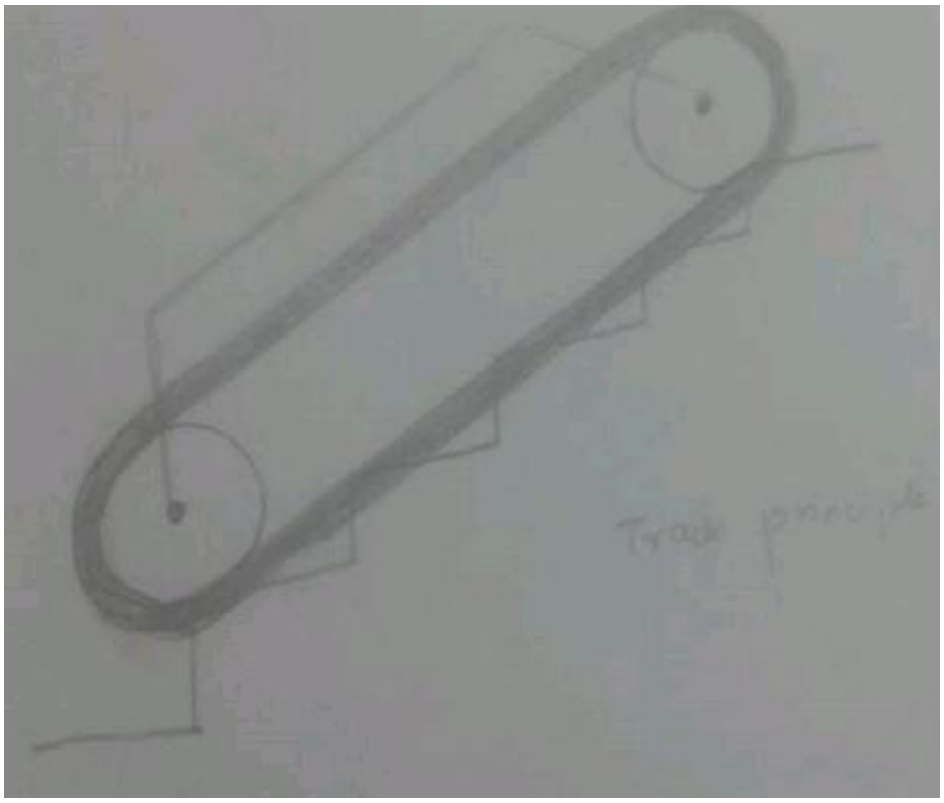
Concept-1[clustered wheel]

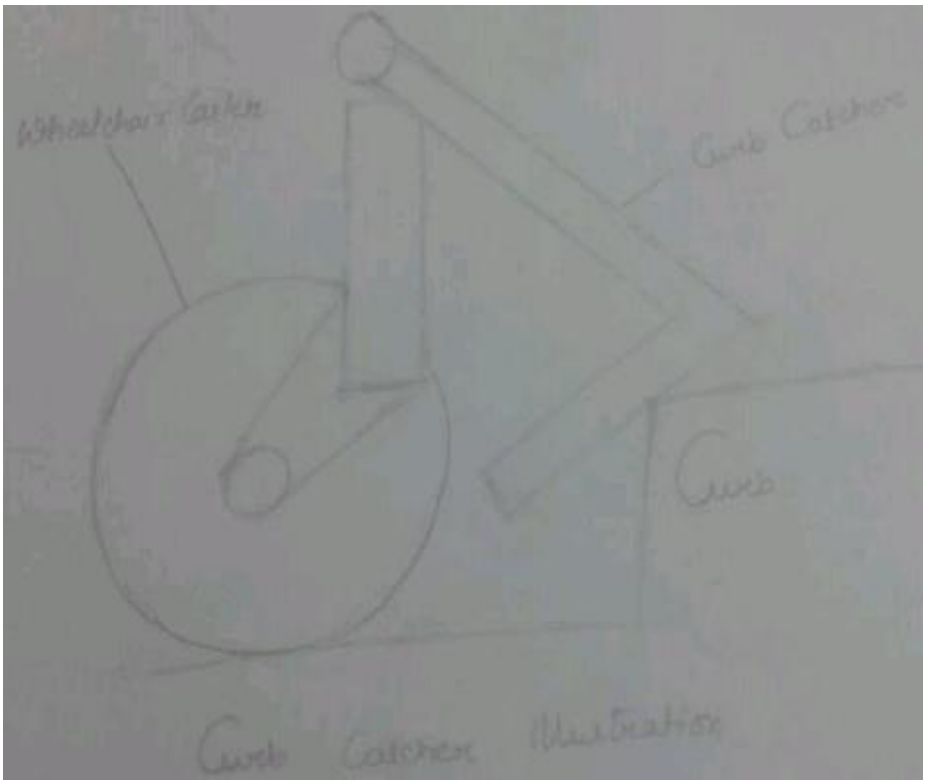


Concept-2[caterpillar wheels]

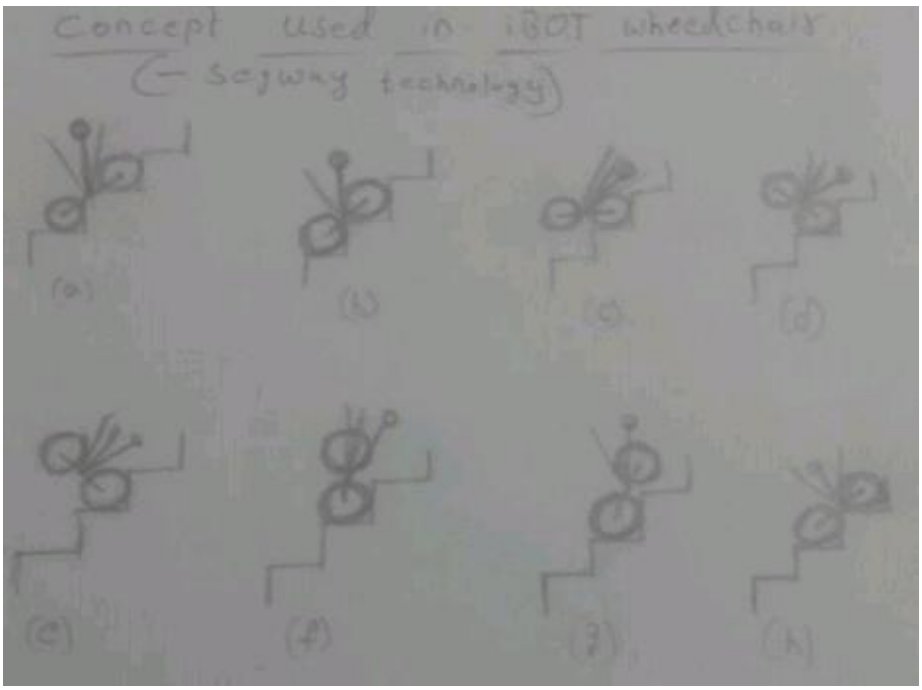


Concept-3[Track]





Concept-4[Ibot]

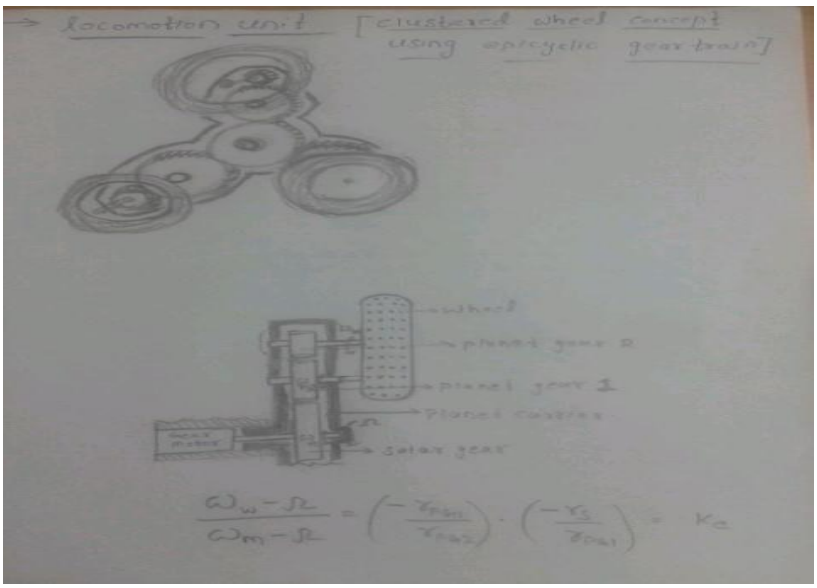


Concept 5

it's far the very last decided on idea. Wheelchair is composed basically of three elements: a frame, a seat and a linkage mechanism connecting body and seat.

the use of handiest one motor locomotion, from rolling on wheels ("advancing mode") to strolling on legs one ("automated mountaineering mode"), sincerely on the

idea of local friction and dynamic situations.

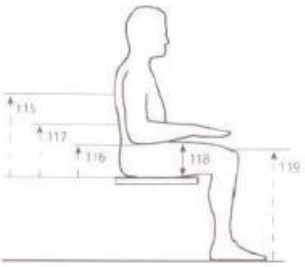


Planetary gear drive

System Level Design Seat

The seat is a tubular structure sporting a chair and a pivoting wheel. The seat consists basically of two tubular systems, related through crossbars, a chair guide and a pipe that ends with a pivoting wheel. Connection points, in tubular structure, are hinges for the linkage mechanism. The seat can move relative to the frame: all through stair hiking operations in fact the wheelchair is moved backwards and reoriented.

The seat is designed ergonomically, thinking about all of the required anthropometric measurements. Parameters considered in conjunction with their measures are as proven below.

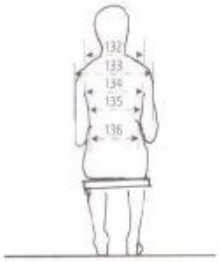


R.No.	Parameters	Definition (brief)
115	Tip of shoulder blade	Lower tip of the shoulder blade (scapula).
116	Elbow rest	Lower most part of the elbow.
117	Waist	Upper margin of the lateral iliac crests (where the belt is worn).
118	Mid thigh	Top of the middle thigh.
		Heights from floor
119	Knee	Uppermost point on the knee (at lower thigh).

Anthropometric measurement

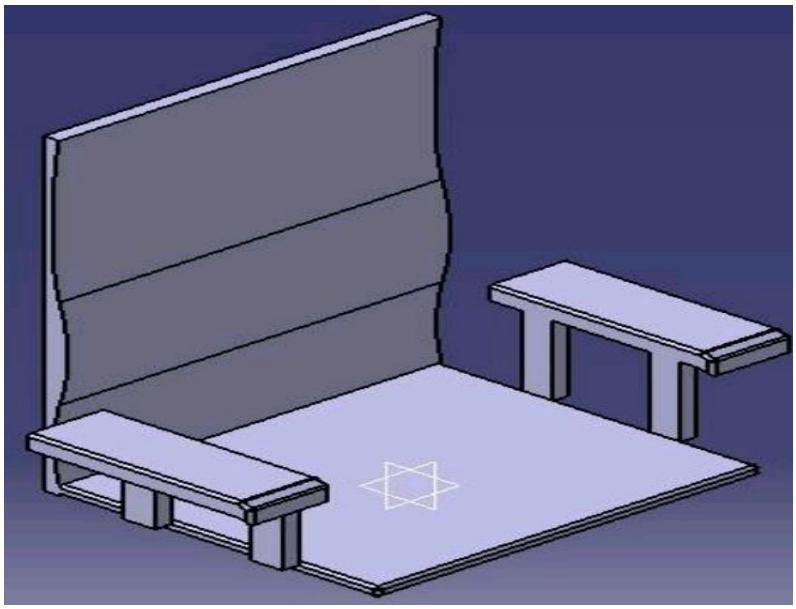
137	**Hip breadth**	Maximum horizontal distance across the hips.

Anthropometric measurement



R.No.	Parameters	Definition (brief)
		Breadths
132	**Bi-acromion**	Maximum horizontal distance across the shoulders, breadth measured between the most lateral points on the superior surfaces of the acromion processes of the scapula.
133	**Bi-deltoid**	Maximum horizontal distance across the shoulders, breadth measured to the protrusions of the deltoid muscles.

Anthropometric measurement

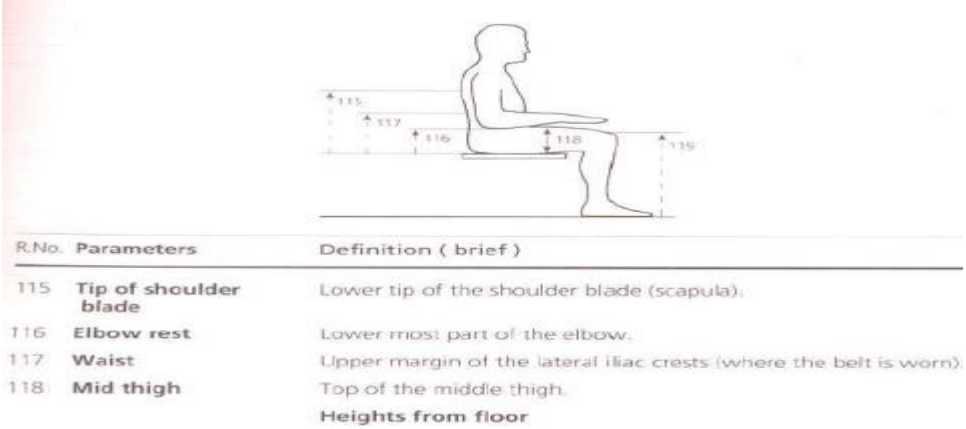


CATIA model seat

Frame

The body consists of a chassis that contains motorized locomotion gadgets, a help for two electrical equipment-vehicles, idle triple wheels units and a battery %. The chassis is composed particularly of

tubular structures, connected by using crossbars; triangular tubular systems at the front assist the triple wheel devices. Connection points are hinges for the linkage mechanism. The triple wheel gadgets consist of a spider, rotating around a crucial axis, with 3 idle wheels positioned at its vertices. Wheel size was chosen on the premise of the consideration that huge wheels can better soak up vibrations due to uneven terrain, whilst small wheels lessen ordinary dimensions. hence, large wheels have been selected for the locomotion unit and for the pivoting wheel, which might be in contact with the ground most of the time, even as smaller ones were chosen for the triple wheel gadgets, in contact with the terrain simplest during the stair hiking operation. the scale of the body are calculated in step with the gap constraints. those space constraints are obtained from top of base of seat from floor and dimensions of chair. Seat top is based totally upon the anthropometric measurements of the parameter 'Knee peak'. in line with the Indian anthropometric measurements, ninety fifth percentile of knee height in sitting posture is 55cm. Assuming 15cm as clearance, a complete of 70cm of gap is considered. therefore, frame dimensions are determined upon the space constraints of (48X63X70) cm.



R.No.	Parameters	Definition (brief)
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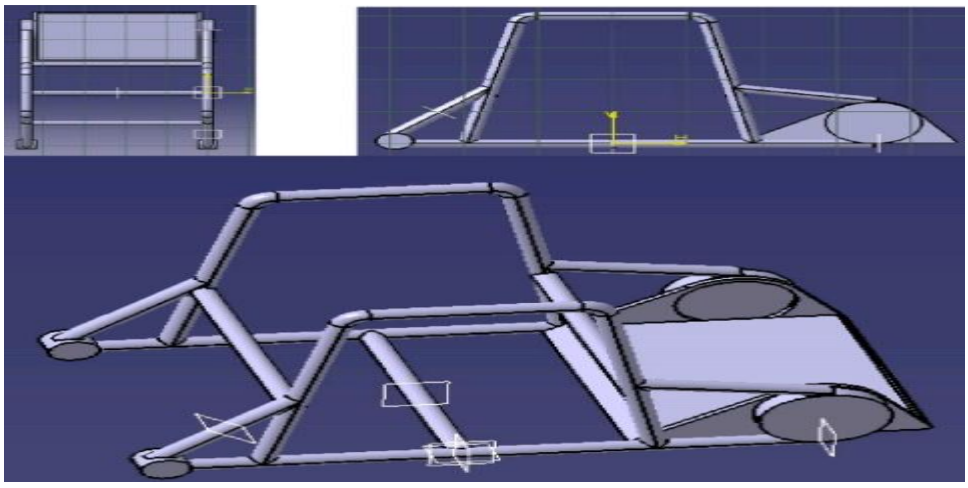
118	Mid thigh	Top of the middle thigh.
		Heights from floor

Anthropometric measurement

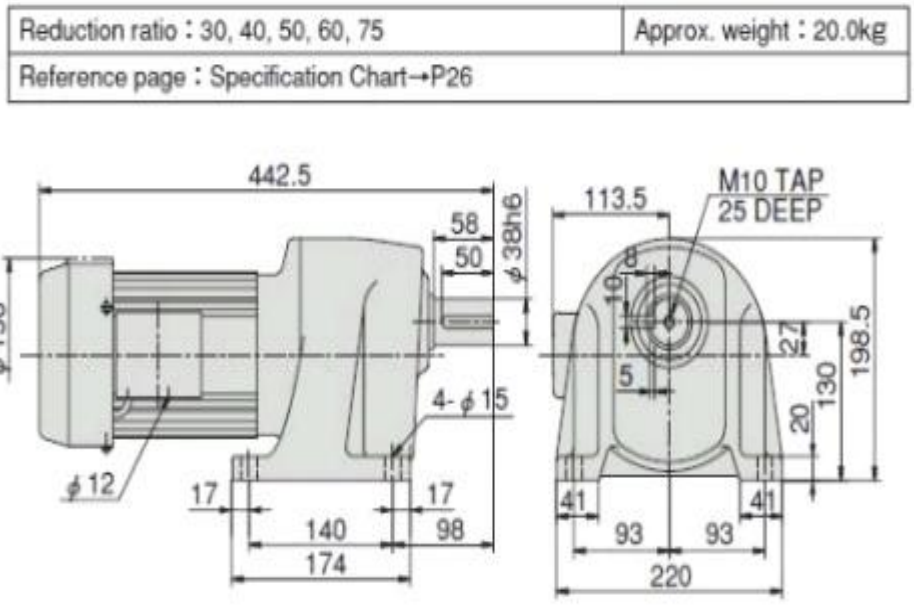


Frame

Gear motor

A tools motor is used as locomotion unit and this movement is transmitted to the clustered wheels. This motor is mounted on a support provided by means of the body as shown. the size and specs of tools

motor are acquired from widespread automobiles available. A gear motor of 750 watt power and one: sixty four reduction tools ratio is used.



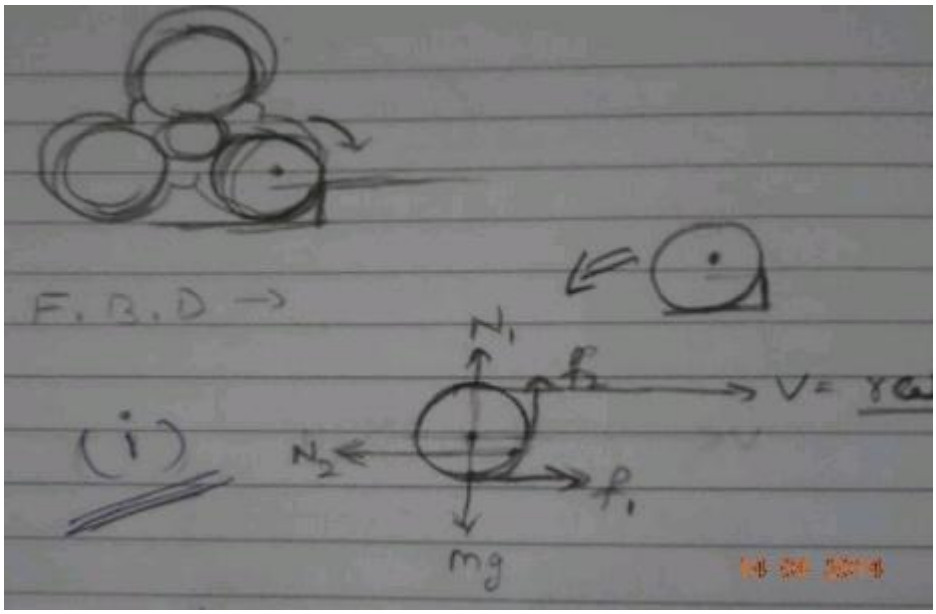
Gear motor

NOMENCLATURE

ωw = rotational speed of the wheel
ωm = rotational speed of the gear motor
Ω = rotational speed of the planet carrier
rPG1 = radius of the first planet gear
rPG2 = radius of the second planet gear
rS = radius of the solar gear
r = radius of the wheel
h = step height
d = step depth
z = number of teeth
M = module of gear wheel
t = tooth thickness

Wheels

Here a clustered wheel concept is being advanced with a purpose to accommodate stair mountain climbing feature. 3 wheels are arranged in a triangular array, such that centers of every of the wheels coincide with vertices of an equilateral triangle. Now the side of an equilateral triangle (s) and radius of the wheel (r) are calculated the usage of positive equations, which are described underneath. inside the following equations, step heights and depths are assumed to lie in the range among (152-203)mm and (254-330) mm respectively. These are taken from ergonomic requirements. Because the wheelchair being designed is supposed for home use, steps would rather be even and so their heights and depths are approximately taken as 150mm and 250mm respectively. Additionally the evenness of these stairs led to the equilateral configuration of wheel association. Case 1: Radius of the wheel (r) > Step top (h);

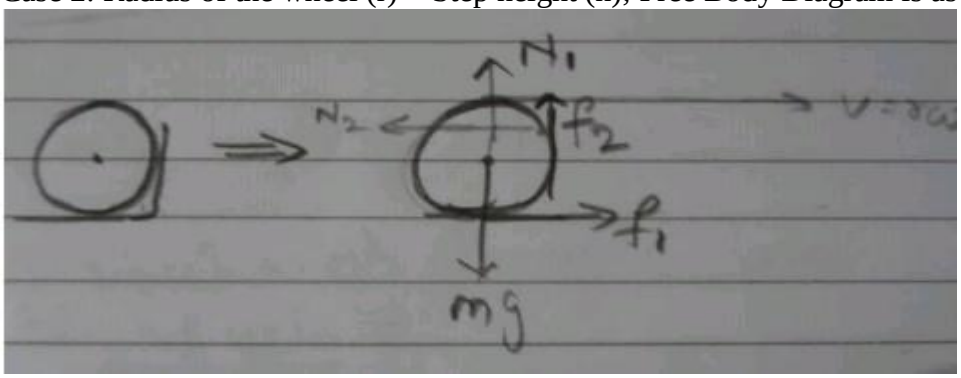


Free body diagram of wheel

Here torque (1) to be applied during stair climbing is given by,

$$1 = [(1 + 2) \times] - [2 \times (- h)] \text{ ---------- (1)}$$

Case 2: Radius of the wheel (r) < Step height (h); Free Body Diagram is as shown.



Free body diagram of wheel

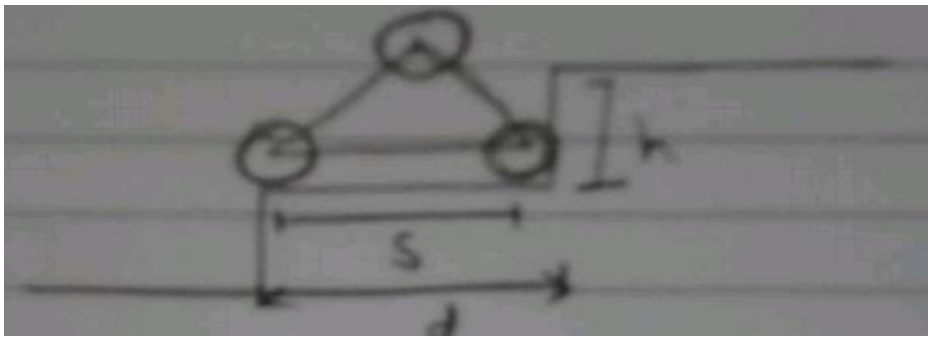
Here torque (2) to be applied during stair climbing is given by,

$$\tau 2 = [(f1 + f2) \times] + [N2 \times (h - r)] \text{ ---------- (2)}$$

Now, from (1) & (2), we can observe $\tau 1 < \tau 2$. So case 2 is desirable, as locomotion unit shifts to the clustered wheels on increased torques, which is suitable for climbing. Therefore radius of each wheel (r) < step height (h).

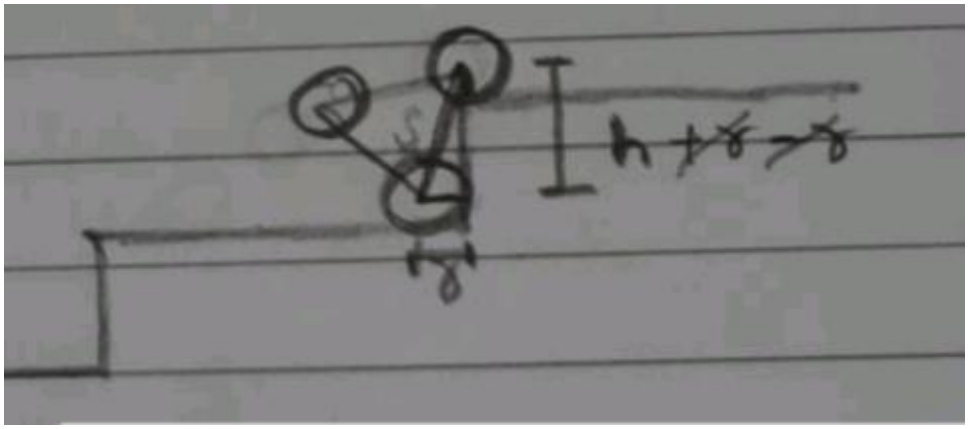
$$\Rightarrow r < 150 \text{ ---------- (3)}$$

Now let'd' be the step depth; 'h' be the step height; 's' be the distance between centers of the wheels arranged in a triangular array. In the stage 1 of stair climbing, following is the situation.



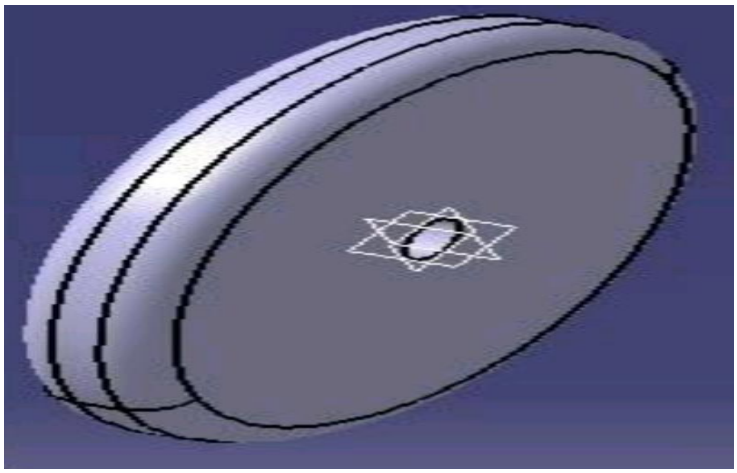
Free body diagram of wheel

From the above figure, we have,
$s + 2r \leq d$ ---------- (4)
Now in the stage 2 of stair climbing,



Free body diagram of wheel

From the above figure, we have,
$s2 \geq r2 + h2$ ---------- (5)
Here, we assume, h=150mm;d=250mm;
Therefore from, (3), (4), (5)
r = 50mm and d = 200 mm (Approximately).
The CATIA model of wheel is as shown below.



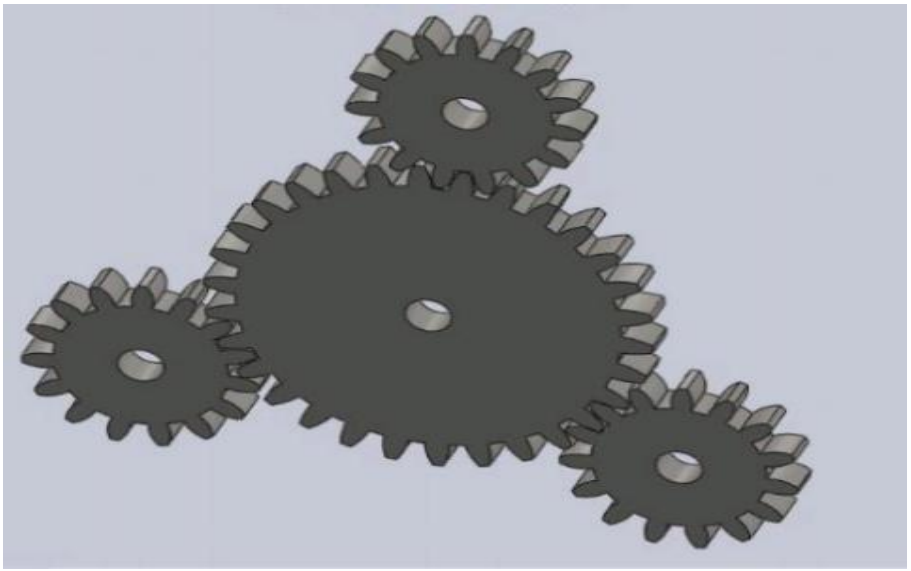
Wheel CATIA model

Planetary Gear train

Transmission of motion from gear motor to the wheels is through this planetary gear train. The specifications of these gear wheels are obtained partly from existing commercial gears used in motorized wheelchairs and partly by customization.

Specifications of planet gear-1: pitch diameter = 30.5mm;
Number of teeth (T) = 10;
Module (M) = 3.05mm;
Tooth thickness (t) = 5mm;
Specifications of planet gear-2: pitch diameter = 15mm;
Number of teeth (T) = 5;
Module (M) = 3.05mm;
Tooth thickness (t) = 5mm;

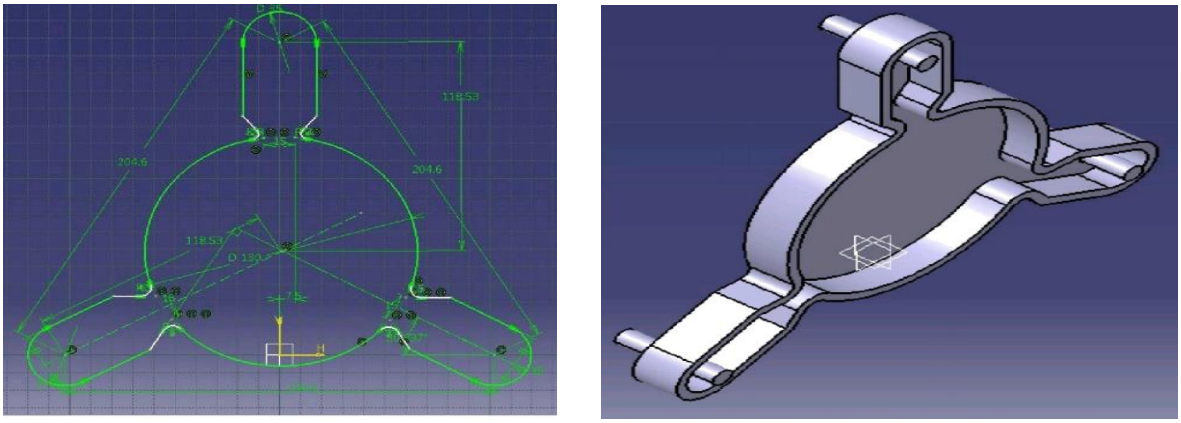
Specifications of sun gear: pitch diameter = 130mm;
Number of teeth (T) = 42;
Module (M) = 3.05mm;
Tooth thickness (t) = 5mm;



Solid work of sub assembly model

Planet Carrier

The shape and size of planet carrier depends on the arrangement of wheels in triangular array and also on the dimensions of gears. As calculated above, distance between centers of wheels (s) is 200mm.



Drawing and model

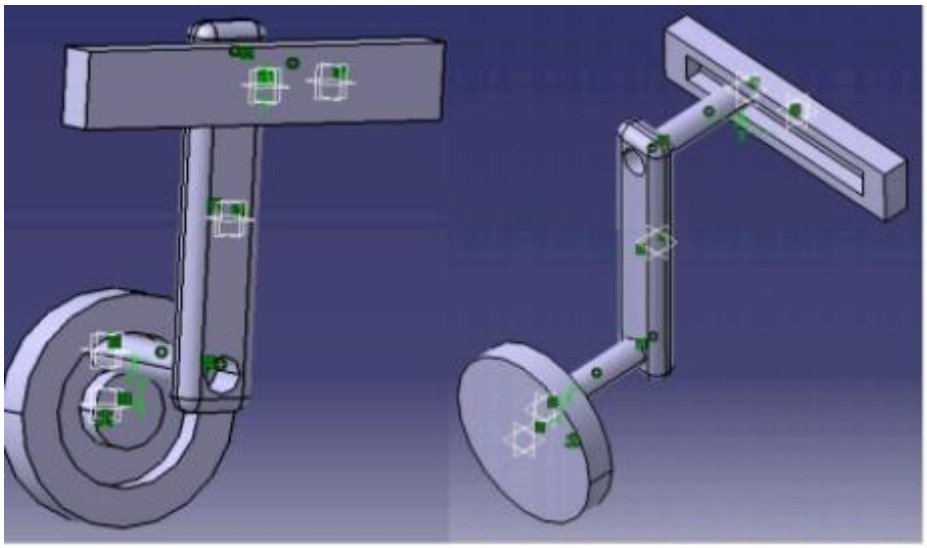
Linkage mechanism

In order to keep the base of the seat horizontal while climbing up or down the stairs, a linkage mechanism is provided connecting the seat and frame together. This mechanism is designed based on the second inversion of 4-bar linkage mechanism. It is similar to whit worth quick return mechanism. Here, a closed loop control is provided with mini servo motor being connected to the 2nd link. Strain gauges are used to feedback appropriate angle to be rotated to acquire stability and making no couple to act on the wheelchair. Here, mini motor keeps the seat in stable position bringing the Centre of gravity down.

The linkage mechanism generates relative motion among the frame and the seat. Throughout stair mountain climbing operations it's far required to accomplish 3 distinct responsibilities: shifting the seat backwards, reorienting it and lifting up the pivoting wheel. Whilst the seat is moved backwards, the centre of mass of the wheelchair is placed in a safe role, and overturning is for that reason prevented.

as soon as the four-bar linkage mechanism become chosen, only its geometry needed to be decided. The four-bar linkage are in an preliminary function (purple) and in a frequent role (inexperienced). A0 and B0 are hinges constructed into the body, designated as (d), A and B are hinges fabricated within the seat, precise as (j). E is the centre of mass of the seat, each link of a 4-bar linkage can be represented in a complicated plane, as described the use of complicated numbers.

As depicted, the locomotion unit is axially joined to the body (zero) but rotationally unfastened by way of way of bearings. The locomotion unit consists of the following elements: equipment motor (1), planet provider (2), solar equipment (3), first planet tools (4), 2d planet tools (5) and wheel (6). The usage of most effective one motor and a transmission device according to locomotion unit, the wheelchair passively modifications its locomotion, from rolling on wheels (“advancing mode”) to on foot on legs (“automatic hiking mode”), consistent with neighborhood friction and dynamic situations.



CATIA model of linkage sub assembly

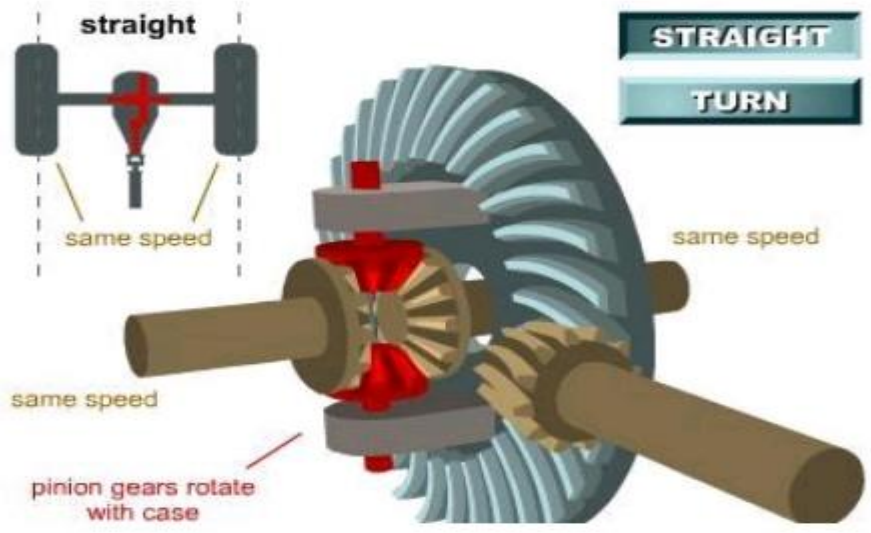
Transmission mechanism

Initially the power from the battery flows to the equipment motor, which is organized collectively battery in an enclosed box. Now the tools motor rotates together with the shaft connected, with as it should be decreased RPM consistent with the required discount ratio of motor. here 'differential gears' are used to transmit the motion from rotating shaft to the wheels with the flexibility for left and right (exterior and indoors) wheels to transport at one-of-a-kind speeds.

This contains turning of the wheelchair when required

The differential gear has three jobs:

- To aim the engine power at the wheels.
- To act as the final gear reduction in the vehicle, slowing the rotational speed of the transmission one final time before it hits the wheels.
- To transmit the power to the wheels while allowing them to rotate at different speeds.



Transmission mechanism

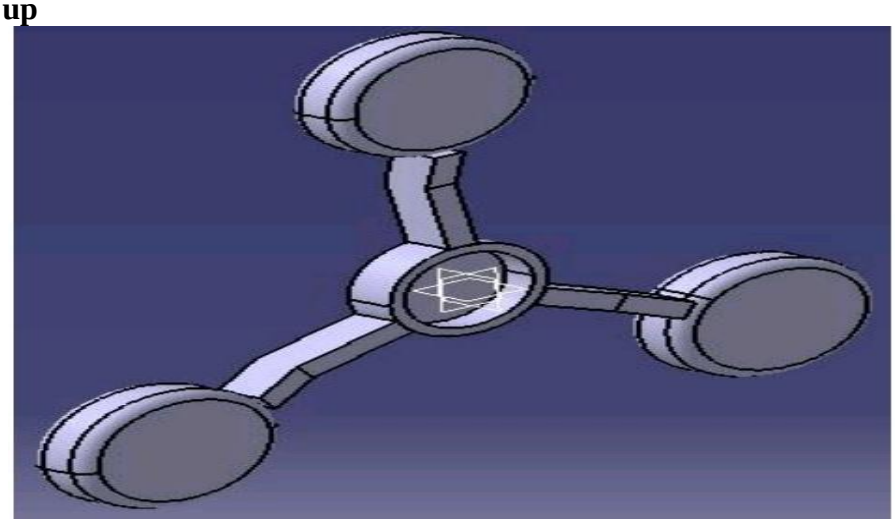
Detailed Design
The detailed design phase includes materials, manufacturing processes and digital mock up.

Materials Frames
Power base chairs may have aluminum, stainless steel, cold-rolled steel, flat steel, tubular steel, or steel frames. The type of material used to construct the frame affects the weight of the frame, and therefore the overall weight of the wheelchair. The type of frame material also can affect the wheelchair's overall strength.

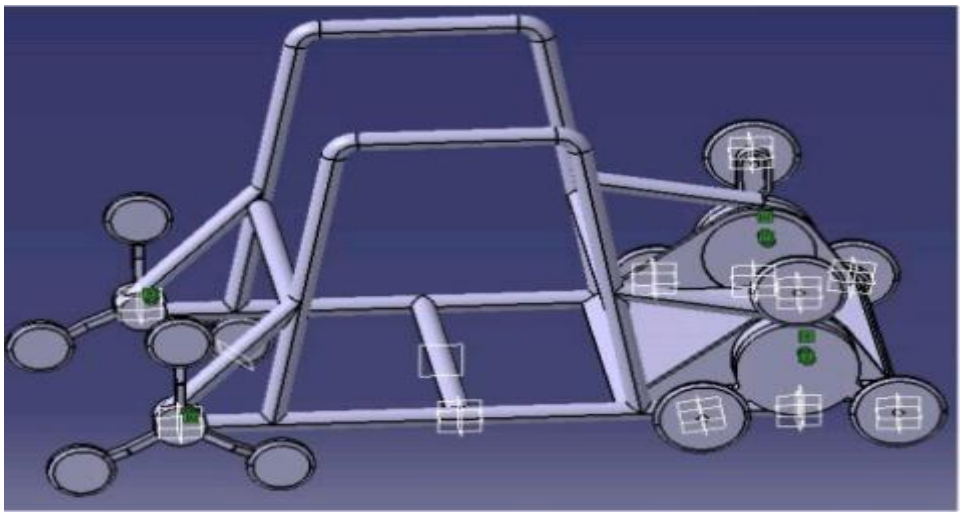
Upholstery
Upholstery for wheelchairs ought to resist each day use in all styles of weather. therefore, producers provide a diffusion of options to customers, starting from material to new synthetic fabrics to leather

Wheels/Tires
Tires vary in size (generally ranging from six to eight inches in diameter, although smaller sizes are also used) and composition (pneumatic, solid rubber, plastic, or a combination of these).

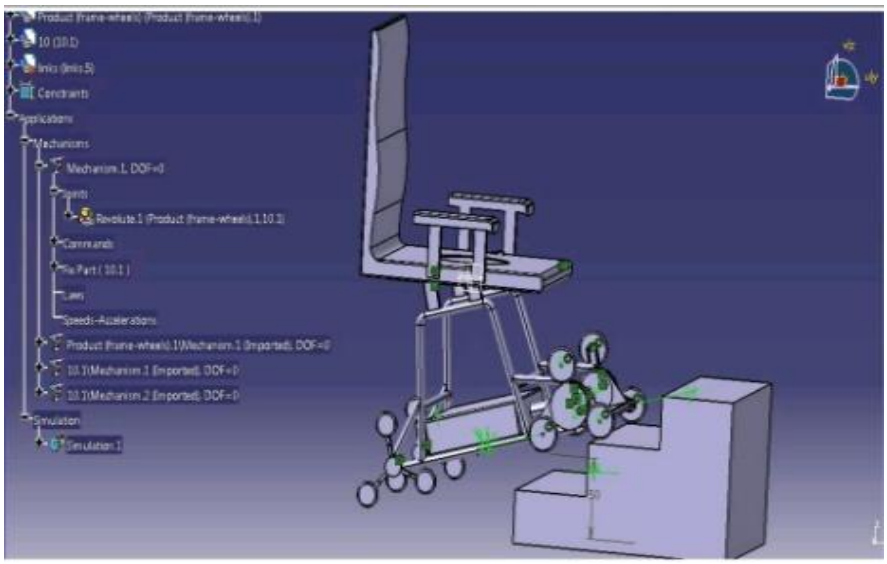
Dial mock up



Idle wheels



Frame wheel assembly



Final assembly of product model

RESULTS & DISCUSSION

The digital and physical mock-ups are developed based on the discussed equations in the sections above. Here the dimensions of the physical model are scaled to half of original dimensions as it is intended to serve as focused physical prototype depicting the structure and basic functionality. The dimensions of original complete model developed in CATIA are as given below.

Final assembly of product model [physical mockup]

a) **Seat**
Backrest - Length = 685mm
Width = 480mm
Base -Depth = 110mm
Width = 480mm
Armrest - Length = 260mm
Width = 90mm
Thickness of chair = 50mm

b) **Frame**
Diameter of tubular section = 25mm
Height of frame = 400mm
Width of frame = 440mm

c) **Wheel Carrier**
Centre to centre distance = 200mm
Wheel diameter = 100mm

d) **Gear motor and battery box**
Length = 320mm
Width = 430mm
Thickness = 90mm

Within the designed model, there are versions in proportional dimensional scaling. These are because of the exclusive percentiles of anthropometric parameters considered in the layout of individual functions of chair. These percentiles to be taken into consideration are primarily based on subjective perceptions arrived at by way of subjective analyses. Also the design of wheels and wheel service are suitable to confined range of staircase dimension versions. as the product is targeted for home use, the regularity in staircases are assumed.

The mechanism for engagement and disengagement of shaft to the solar equipment and the wheel service are to be advanced further, to house the switching among stair climbing mode and moving on flat floor mode. This may be furnished both manually or mechanically by way of putting the most restrict for torque in flat ground mode.

CONCLUSIONS

This project involves the design of an ergonomically designed electric powered wheelchair for home use by Indian vintage aged humans. Stair mountain climbing capability turned into the principle recognition in its shape and mechanism. The product included 3 modules viz. seat, hyperlinks and frame. Seat dimensions had been calculated following the Indian Anthropometric requirements. The frame and wheels are designed and developed via the mathematical calculations based totally upon from the statistical information of dimensions of staircases in Indian houses. form, capability, technology and structure of the product also are evaluated. Digital Mockups of character components had been advanced in CATIA and assembled to form the final product. The stair climbing mechanism is simulated in digital surroundings. The bodily and focused prototype indicating the shape and functionality is advanced the usage of thermocol material. The wheel providers are developed by way of the use of speedy Prototyping technique (Fused Deposition Modeling) the usage of ABS (Acrylo Butadiene Styrene) material. Wheelchair is embedded with a few extra features like incorporated commode facility, after accumulating costumer necessities from special subjects.

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