Design And Development Of Automatic Wheelchair And Bed For Old-age Home

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The way we proceed……

- Introduction
- Objectives
- Working plan
- Literature Survey & Hospital Survey
- Project Concepts
- Project Design
- Animation video
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- Input and Output parameter
- Equipment Used and their description
- Problem Faced during development
- Development
- Working Video
- Cost Analysis
- Conclusion
- References

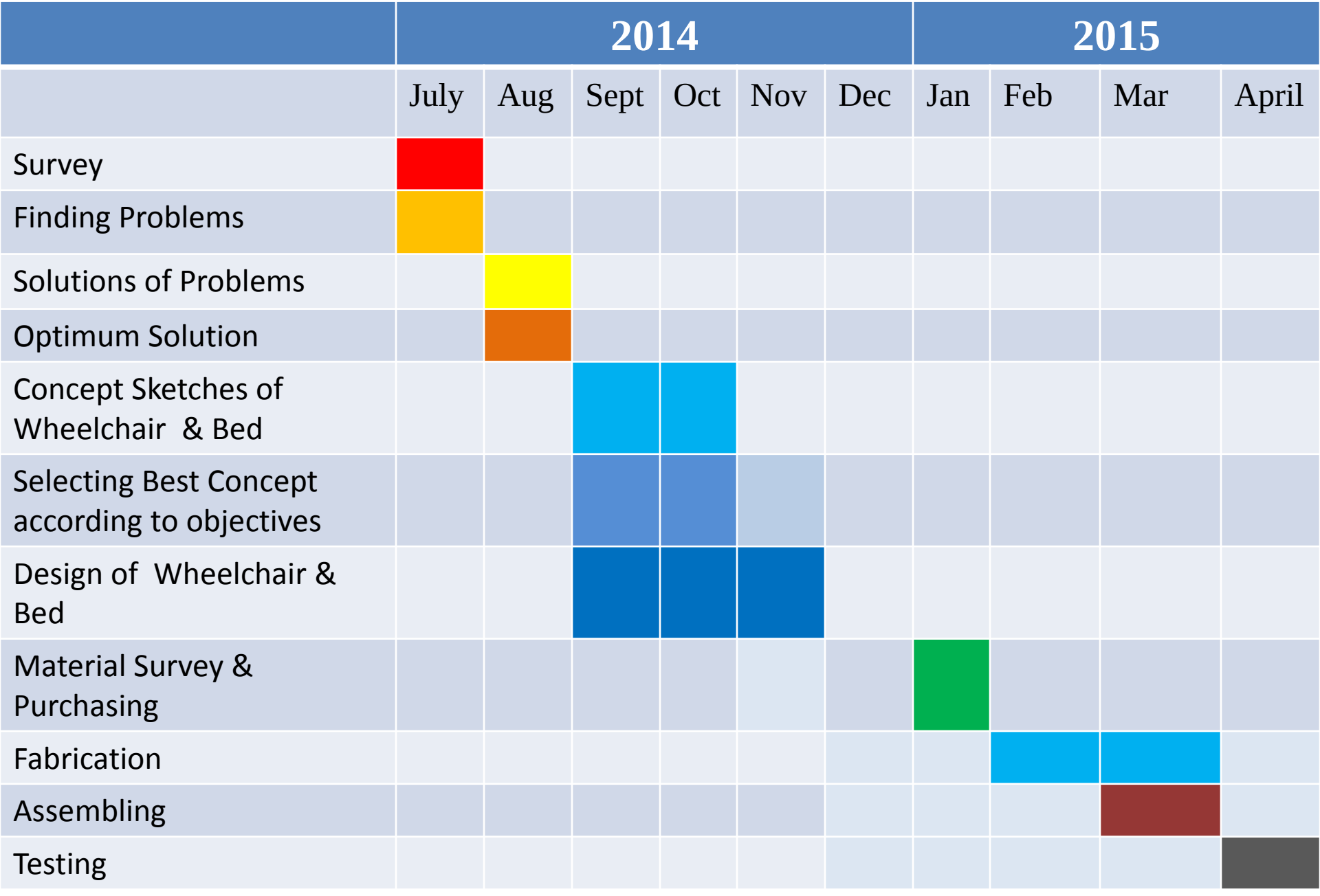
Introduction

- The need for automatic Wheelchair is especially present in care of immovable people (people with persistent vegetative state, paraplegia, stroke and spinal cord injuries), where the care requires a lot of time and manpower. This report is the result of a design and development of an automated multifunctional Wheelchair that would perform all functions present in today's Wheelchair (Wheelchair with adjustable portion of back rest and leg rest and also convert to bed to wheelchair and vice versa and also remote control with which we can provide all necessary movement) as well as new functions of appropriate Wheelchair sections (leg positions adjusting). It is expected that this new automatic Wheelchair would enable people's better medical care, and would greatly reduce time and manpower to the old-age home staff.

Objectives

- Give the comfort to the senior adults(Age: 65+)
- Bedsore prevention for support
- Commode facility in wheelchair
- Improve balance and postural stability of Old-Age people
- Convert Sleeping Position from sitting position easily
- Prevention of incapable of surviving serious injuries
- Easy movement one place to another place
- Wheelchair and Bed can attached together
- Specific service to the human in a safe and comfortable manner
- Focusing on mobility assistance for bedridden persons

Working Plan



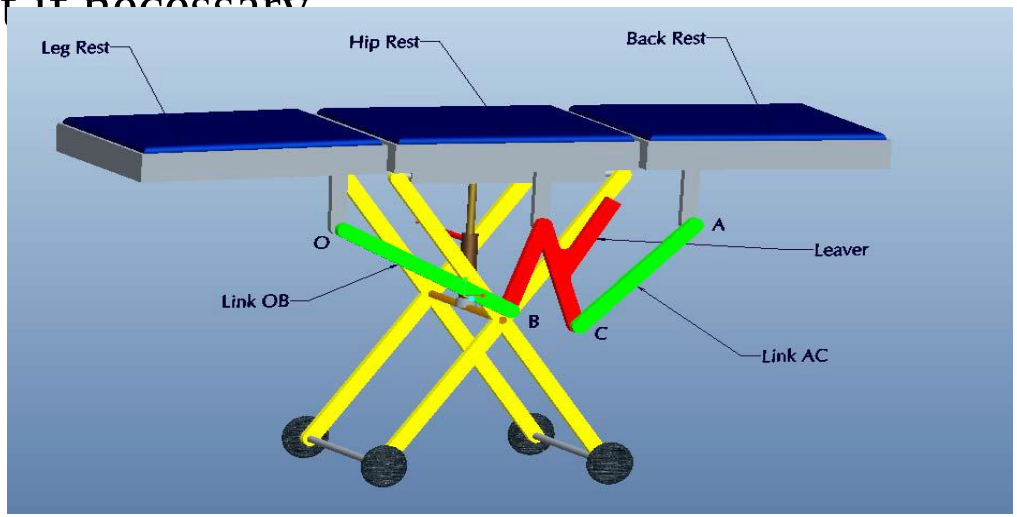
LITERATURE SURVEY

- **Mohan Kumar R. and et al. (2012)**

  - Found Design of Multipurpose Wheel Chair for Physically Challenged and Elder People. The design of wheel chair started by means of literature review to know its evaluation from earlier to the present generation. Market study was carried out to know the present competitors available in the market with cost analysis of the existing product.

Multi Purpose Wheel Chair

- **Ehsanullah Khan and et al. (2011)**
  - He says synthesis of trolley cum wheelchair for patient handling. Handling of patient from hospital bed to CT-Scan, MR Scan, X-Ray, Sonography centre etc is a cumbersome and tedious job. Generally from bed, the patient is moved to trolley manually. Three to four persons lift the patient and keep him on the stretcher. The trolley is moved to lift if necessary



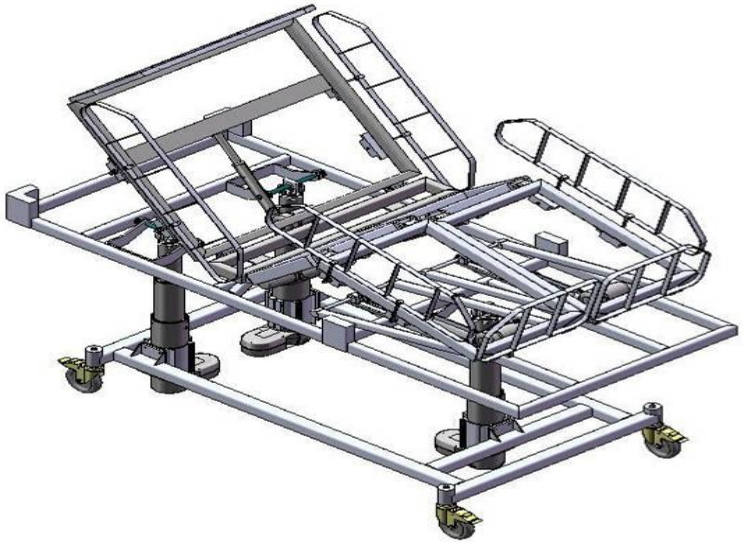
Trolley cum Wheel Chair

- **Jingtao.Chen and et al. (2013)**

  - Found design of the wheelchair bed. People's request, in this paper by considering the wheelchair on the research of the front foot and back structure, finally decided to use in forefoot plate rack mechanism, backplane using slider-crank mechanism, so as to achieve transformation between the wheelchair and the bed. And using computer application software for 3d drawings of drawing and carry on simulation test.

Design of Wheelchair

- **Nenad Pavlović and et al. (2010)**
  - Found development of multifunctional hospital bed. The need for multifunctional hospital beds is especially present in care of immovable patients (patients with persistent vegetative state, paraplegia, stroke and spinal cord injuries), where the care requires a lot of time and manpower.



Multifunctional Hospital Bed

- **Meng-Hui Hsu and et al. (2009)[8]**
  - Found dual-purpose wheelchair mechanism designs. A wheelchair with dual-function of sitting and lying is usable to the users no matter what he sits or lies. In addition, if the rear wheels of the dual-purpose wheelchair are designed as movable ones, the whole mass-center of the wheelchair can move between the rear and front wheels of the chair.

Dual Purpose Wheelchair

- **Po Er Hsu and et al.(2013)**
  - He found seat adjustment design of an intelligent robotic wheelchair based on the stewart platform. A wheelchair user makes direct contact with the wheelchair seat, which serves as the interface between the user and the wheelchair, for much of any given day. Seat adjustment design is of crucial importance in providing proper seating posture and comfort.

Intelligent Wheelchair

HOSPITAL SURVEY

• **Lions Hospital, Mehsana**

• **Hcg Cancer Hospital, Ahmedabad**

• **Sterlling Hospital, Ahmedabad**

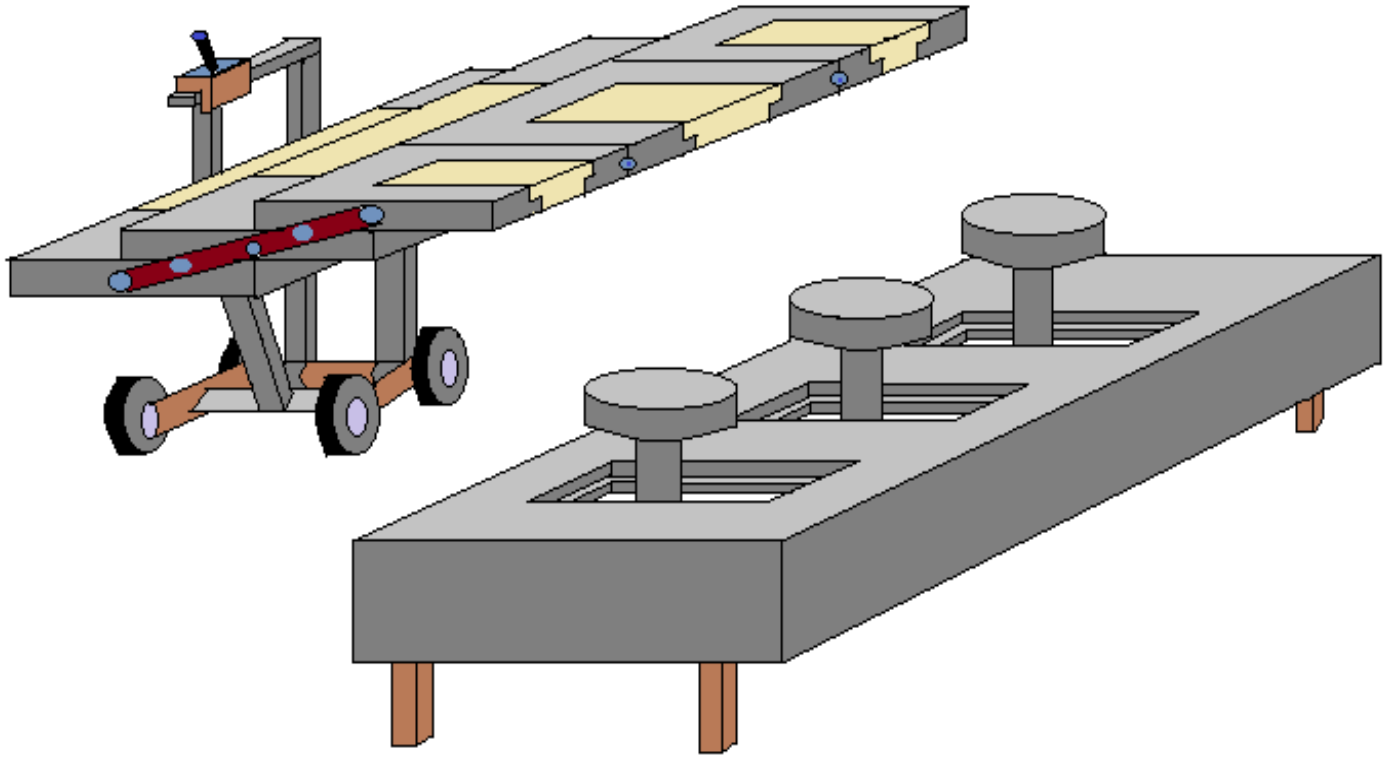
- **Sai Krishna Hospital, Mehsana**


- **Sal Hospital, Ahmedabad**

PROJECT CONCEPTS

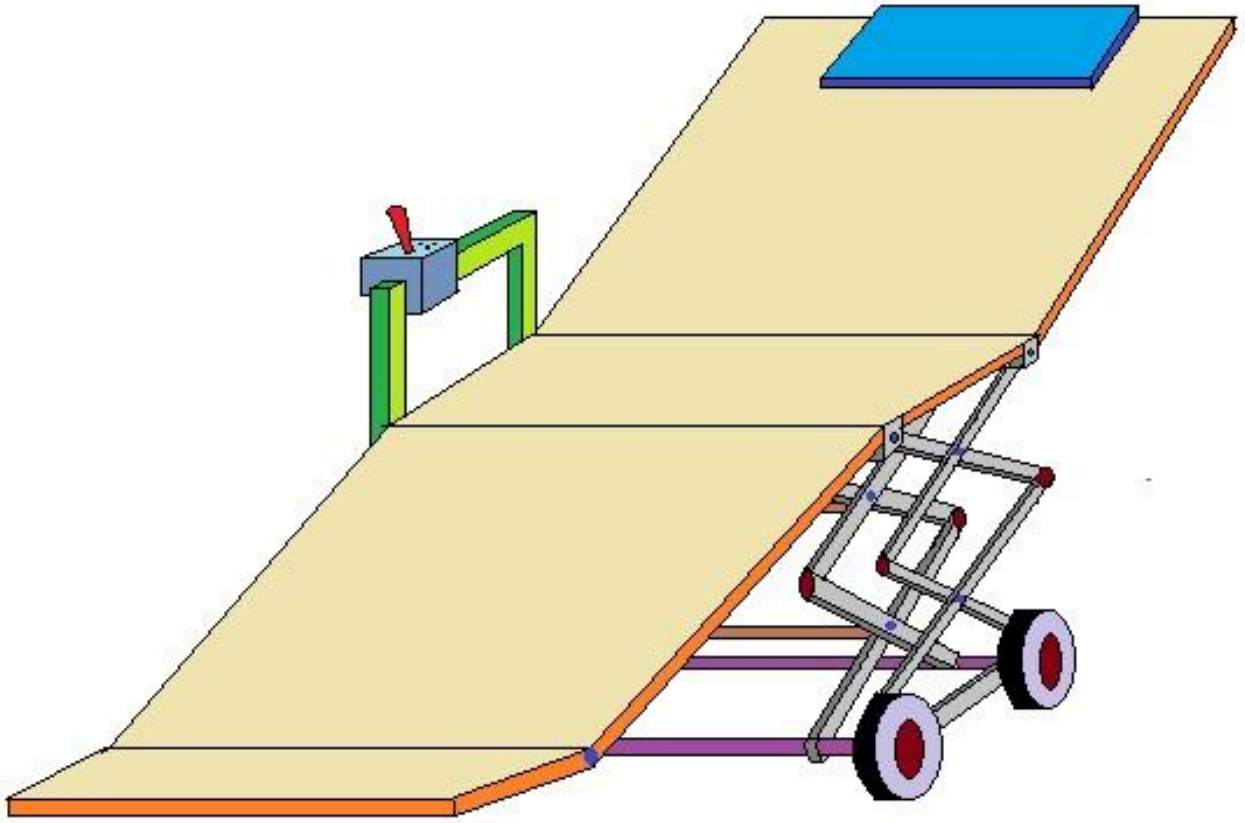
1. Bed & Wheel Chair With Slider Mechanism

➢ This concept is based on the slider mechanism of extension ladder mechanism also hydraulics provided in the bed.



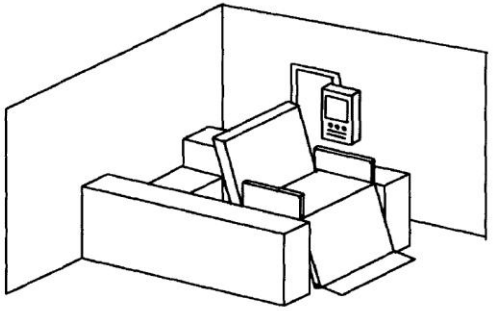
2. Bed & Wheelchair with Scissor Lifter Mechanism

- This concept is containing Scissor lifter mechanism.

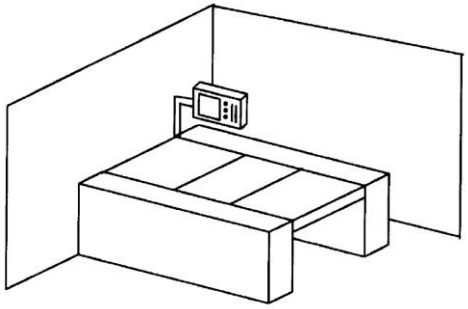


3. Ejectable Wheelchair From Bed

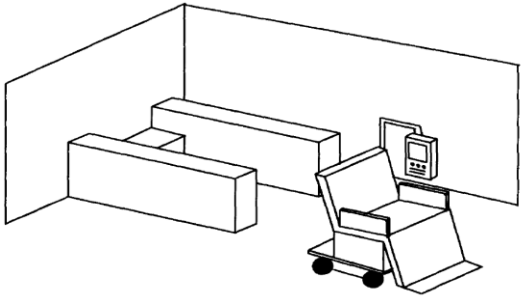
➢This concept is just different concept from above two concepts. In this concept the bed is fixed and chair is removed from the bed. The different position is shown in below figure.



Schematic of Hybrid Bed/Chair System in Seated Position



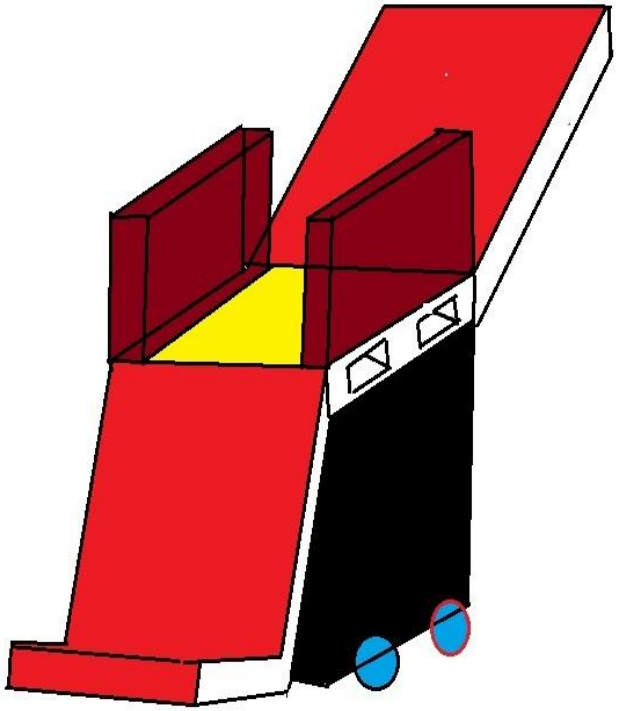
Schematic of Hybrid Chair/Bed System in Lying Position



Schematic of Hybrid Bed/Chair System in Transit

4. Bed & Wheelchair with Fork Lifter

➢It is also different concept from above concept. It is a concept of fork lifter mechanism.



5. Wheelchair is converting into bed by using lifting mechanism and joystick controllable

➢The wheel chair and bed are very convenient for joystick controllable automatic wheelchair with side flexible portion which is different from each other and attached together with mechanism and also commode facility on wheelchair which is very convenient for Old-Age Home.

PROJECT DESIGN

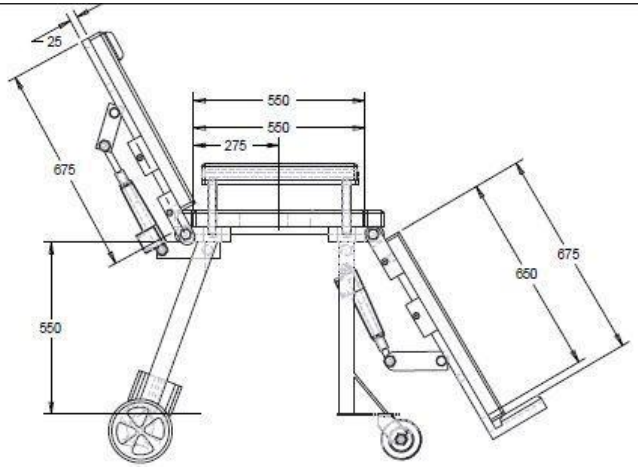
- Design of wheelchair

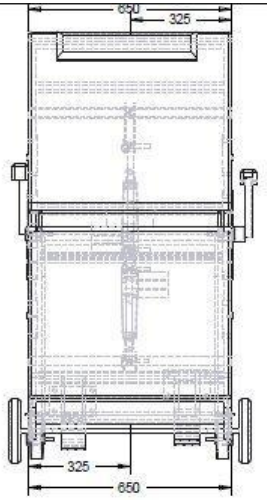
- Design of wheelchair converted into Bed

- Design of Bed

- Design of whole assembly of Wheelchair and Bed

- Dimensions of wheelchair assembly





[ALL DIMENTIONS ARE IN 'MM']

Dimensions	(inch)
Overall length	78”
Overall height	53”
Height from bottom to seat	30”
Overall width	27”

Animation

DESIGN CALCULATION

- Material Used for Development

1) M. S. section of 25*25 mm
2) M. S. section of diameter 30 mm
3) M. S. section 50*50 mm
4) M. S. section 66*33 mm
5) M. S. Plate of 2mm
6) Bolt and nut of 10 mm diameter and 4 inches length
7) 22 mm diameter hollow bar
8) Polyurethane
9) Spunch (foam)
10) Leather cover
11) Waterproof sheet
12) Castor
13) Wheel
14) Bearing(SKF-6204)

- M.S Material Properties

Material	Mild Steel
Density	7200 kg/m^3
Thermal expansion	10.1 - 16.6*10^{-6} ($mm/^0c$)
Young's modulus	68.9-207 Gpa
Poisson ratio	0.23-0.3
Melting point	1230-1530 (^oc)
Ultimate tensile strength	450-500 Mpa

- M.S Material Sections used in Development

Cross Section (mm)	**Kg /20ft**	**Kg/ft**
66*33	25	1.25
60*40	14.70	0.735
50*50	17	0.85
25*25	7	0.35
Φ25	10	0.5

- M.S Material Sections used in Wheelchair

Cross Section	Feet	Weight (kg)	Weight (Newton)
60*40	6.54	4.81	47.19
50*50	3.61	3.07	30.12
25*25	32.79	11.47	112.58
Φ25	7.79	3.90	38.259
TOTAL WEIGHT		23.25	228.08

- M.S Material Sections used in Bed

Cross Section	Feet	Weight (kg)	Weight (Newton)
66*33	13.69	17.12	167.92
60*40	24.69	18.15	178.04
50*50	13.30	11.31	110.91
25*25	4.59	1.61	15.77
TOTAL WEIGHT		48.19	472.74

- Human Weight Calculation

DIFFERENT PART OF HUMAN BODY	**WEIGHT IN (%)**	**WEIGHT OF HUMAN BODY PARTS (KG)** (IF WE SUPPOSE WEIGHT IS 120 KG.)
Trunk (Chest, back and abdomen)	50.80	60.96
Thigh	9.88	11.856
Head	7.30	8.76
Lower leg	4.65	5.58
Upper arm	2.7	3.24
Forearm	1.60	1.92
Foot	1.45	1.74
Hand	0.66	0.792
Others	20.96	25.152

- Load calculations
  - Load on front casters

Weight of Body = 23.25 kg

Weight of Body (Newton) = 228.08 N

Weight of Screw Motor = (2*1.25) = 2.5 kg = 24.525 N

Inclination Angle (θ) = 10^{o}

$F_{front(vertical)}$ = [228.08 + 24.525 + 1177.20] = 476.6016 N

$F_{front(incline)}$ = [$F_{front(vertical)}$ * COS θ] = [476.6016 * COS10]
= 469.36 N

  - Force on each caster

F_{F1} = $F_{front(incline)}$/ 2 = 234.68 N

- Load on rear wheels

Weight of Body = 23.25 kg

Weight of Body (Newton) = 228.08 N

Weight of Human Body = 120 kg = 1177.20 N

Weight of Screw Motor = (2*1.25) = 2.5 kg = 24.525 N

Inclination Angle (Φ) = 20^0

$F_{rear(vertical)}$ = [228.08 + 24.525 + 1177.20] = 953.203 N

$F_{rear(incline)}$ = [$F_{rear(vertical)}$ * COS θ] = [953.203 * COS20] = 895.71 N

- Force on each wheel

F_{F2} = $F_{rear(incline)}$ / 2 = 447.858 N

- Load on back rest portion

Link inclination (α) = 30^0
Weight of Human Body (Back) = 40 kg
Weight of Frame(Back) = 15 kg

Force (F) = (40+15)*9.81 = 539.55 N
Force (actual) = F * sinα = 269.775 N

- Load on leg rest portion

Link inclination (β) = 55^0
Weight of Human Body (Leg) = 15 kg
Weight of Frame(Leg) = 15 kg

Force (F) = (15+15) * 9.81
= 294.3 N

Force (actual) = F * sinβ
= 241.070 N

- Stress calculation

  - Stress on front caster

    Front wheel shaft diameter(d_1) = 10 mm

  - Bending stress

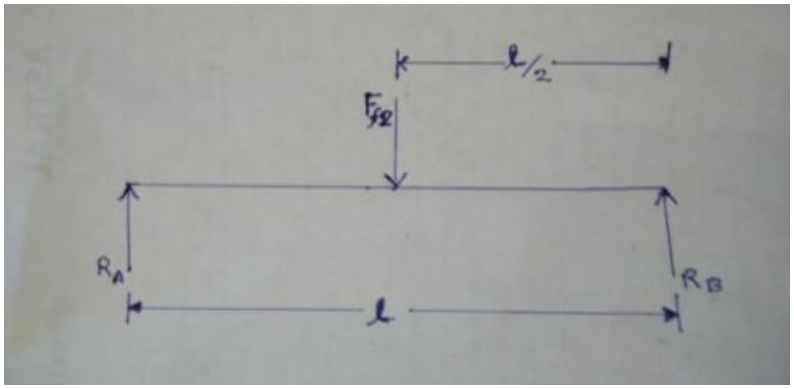
    $\sigma_b = \frac{My}{I}$

    Moment = F_{F1}* (L / 2) = 234.68 * 20 = 4693.6 N.mm

    Y = $d_1/2$ = 5 mm

    I = $\frac{\pi}{64}(d_1)^4$ = $(10)^4$ = 490.625 mm^4

    σ_b = 47.832 N/mm^2



  - Shear stress

    $\tau = \frac{TR}{J}$

    Torque(T) = F_{F1}* (L / 2) = 234.68 * 20 = 4693.6 N.mm

    R = $d_1/2$ = 5 mm

    J = $\frac{\pi}{64}(10)^4$ = 981.625 mm^4

    τ = 23.91 N/mm^2

- Stress on rear wheel

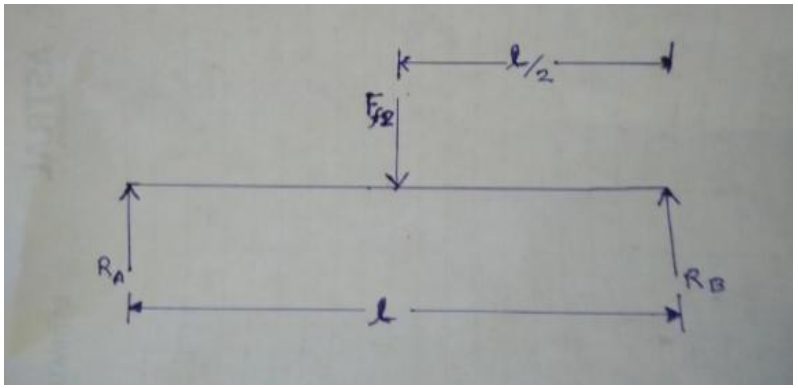
Rear wheel shaft diameter(d_2) = 12 mm

- Bending stress

$$\sigma_b = \frac{My}{I}$$

Moment = F_{F2}*(L / 2) = 447.858 * 50 = 22392.9 N.mm

Y = $d_2/2$ = 6 mm



$$I = \frac{\pi}{64}(d_2)^4 = (12)^4 = 1017.36 \text{ mm}^4$$

σ_b = 132.06 N/mm^2

- Shear stress

$$\tau = \frac{TR}{J}$$

Torque(T) = F_{F2}* (L / 2) = 447.858 * 50 = 22392.9 N.mm

R = $d_2/2$ = 6 mm

$$J = \frac{\pi}{64}(12)^4 = 2034.72 \text{ mm}^4$$

τ = 66.03 N/mm^2

- Stress on back portion

  Bolt diameter (d3) = 10 mm

- Bending stress

  $\sigma_b = \frac{My}{I}$

  Moment $= F_{actual} * (l / 2) = 269.775 * 20 = 5395.5$ N.mm

  $Y = d_3/2 = 5$ mm

  $I = \frac{\pi}{64}(d_3)^4 = (10)^4 = 490.625$ mm^4

  $\sigma_b = 54.98$ N/mm^2

- Shear stress

  $\tau = \frac{TR}{J}$

  Torque(T) $=$ Factual* $(l / 2) = 269.775 * 20 = 5395.5$ N.mm

  $R = d3/2 = 5$ mm

  $J = \frac{\pi}{64}(10)4 = 981.25$ mm4

  $\tau = 27.49$ N/mm2

- Stress on leg portion

  Bolt diameter (d_3) = 10 mm

- Bending stress

  $\sigma_b = \frac{My}{I}$

  Moment $= F_{actual} * (l / 2) = 241.070 * 20 = 4821.528$ N.mm

  Y = $d_3/2$ = 5 mm

  $I = \frac{\pi}{64}(d_3)^4 = (10)^4 = 490.625$ mm^4

  $\sigma_b = 49.13$ N/mm^2

- Shear stress

  $\tau = \frac{TR}{J}$

  Torque(T) $= F_{actual} * (l / 2) = 241.070 * 20 = 4821.528$ N.mm

  R = $d_3/2$ = 5 mm

  $J = \frac{\pi}{64} (10)^4 = 981.25$ mm^4

  $\tau = 24.568$ N/mm^2

- Factor of Safety

$$\text{F.O.S.} = \frac{Ultimate\ tensile\ stress\ of\ Material}{Maximum\ stress\ generated\ in\ material}$$

$$= \frac{450}{132.06}$$

$$= 3.40$$

- Speed calculation of wheelchair

Radius of rear wheel (R) = 101.60 mm

Periphery = $2\pi R$ = 638.048 mm

$N_{1(\text{with load})}$ = 70 rpm

$N_{2(\text{without load})}$ = 85 rpm

$V_{1(\text{with load})} = P*N_1$

$$= \frac{638.048 * 70}{60 * 1000}$$

= 0.744 m/s

$V_{2(\text{without load})} = P* N_2$

$$= \frac{638.048 * 85}{60 * 1000}$$

= 0.9039 m/s

- Speed of back rest portion & leg rest portion

	BACK REST PORTION	LEG REST PORTION
WITH LOAD	0.174 rad/sec	0.1889 rad/sec
WITHOUT LOAD	0.244 rad/sec	0.283 rad/sec

- Bearing material properties

Ball Bearing Type	Deep Groove
Bore Type	Parallel
Cage material	Steel
Bore (mm)	20
O/D (mm)	47
Race Width (mm)	14
Load withstand (KN)	13.5
Limiting speed (rpm)	10000
Static load rating(KN)	6.55
Race type	Plain

- **Input and Output parameter**

Input parameters	Output parameters
Battery (24 V-150 MAh)	Weight can withstand and lift Up to 120 kg
PMDC motor	Wheelchair velocity - 3.250 km/hr
Screw motor	Stroke speed :- 8 mm /s

- Metal Joining:
  - Permanent Joining
  - Temporary Joining

  - Permanent Joining:-

    Permanent fastening can be done by electric arc welding.

  - Temporary Joining:-

    Temporary fastening can be done by bolt and nut.

- Equipment used

- PMDC Motor

  Voltage- 24 volt

  Ampere- 3 amp

  Power- 0.25 Hp

  Rpm without gearbox - 1440 rpm

  Rpm with gearbox - 85 rpm

  Motor shaft dia. - 10mm

- Screw motor

  Voltage - 24 volt

  Ampere - 2.5 amp

  Power - 60 watt

  stroke length - 17 cm

  shaft dia. - 25mm

  Output - 5mm/sec as per above input

- Problem Faced

1) The main problem we faced is, which type of material we should used, after few failure we conclude that low weight and high strength material we should use.
2) The second problem is of screw-motor(used for up and down motion of back and lower portion of wheelchair) as the fix stroke length, we cant lift the up portion as horizontal(0^{o}).
3) The link and their arrangement.
4) The motor used for wheelchair for its motion, after a long research in market we find that, as per our requirement we should use PMDC motor(permanent magnet dc motor).

Continue…

5) The fixing of a dc motor to the wheel of the wheelchair, how to couple the both shaft of motor and wheel than we found in the market but no couple found in the market, than we made a coupling as per our requirement and solve that problem.

DEVELOPMENT

Working video

• Cost Analysis

	Product Name	**Price per piece**	**Total price (Rs)**
1	PMDC Motor	(2*8000)	16000/-
2	Screw Motor	(2*10000)	20000/-
3	M.S Material for different section used in wheelchair		12000/-
4	Wheel and Caster		3000/-
5	Water proof sheet (foam)		18000/-
6	Others		6000/-
	Total		**75000/-**

Available wheelchair in market (only wheel motion):-

1) Wildcat folding power wheelchair (www.Amazon.com) Price:- Rs1,20,000 /-
2) Smart Chair Electric Wheelchair (www.Amazon.com) Price:- Rs1,10,000/-
3) Power Wheelchair KP 10.3 (www.Bay Hatkel.com) Price:- Rs1,11,500/-
4) Karma Power Wheelchair KP 10.35(www.Bay Hatkel.com) Price:- Rs1,12,000/-

Conclusion

- We conclude that, on the basis of our hospital, old-age home and market survey, we made a best design of wheelchair and bed for old age home people. We also provide the up and down motion of back and leg portion and also we automate (means remote control) forward, backward motion.
- The benefits of our project is:-
    - Ease to maintain
    - Customized usability
    - Easy adjustable
    - Durable
    - High strength
    - Elegant design
    - Cost benefit

- Power consumption:-

Power = voltage * Current

Input voltage= 24 Volts

Input Current= 5 Ampere

Power = 24*5= 120 Watts

Market References

- Tekson Hydraulic Corporation, odhav G.I.D.C. Ahmadabad–382415, Mo. :- +919953363703
- Bharat Machinery Electric stores, 4, Maruti complex highway road, unjha, Opp. Marshal threshar, Mehsana-384170, Mo. :- +919825315216
- Libra motors, Plot No. 296, odhav road, odhav Gidc, Ahmadabad-382415
- Jacktech Hydraulic, A/433 odhav Gidc, Opp. Bhikshuk gruh, near apna bazar gas godown, Ahmadabad-382415 Mo. :- +919825199005
- Parth Steel, 3, Maruti complex highway road, unjha-384170, Mo. :- +919825577576
- Kanaiya Plywood and Hardware, Jay-vijay society road, unjha-384170, Mo. :- +919898072173
- Rushabh Bearing Company, 2, Shreeram cloth market, Relief road, Ahmadabad-380002, Mo. :- +919327054302
- Kohinur Engineering Works, near V-Mart, Opp. Pasabhai petrol pump, Mehsana-384002
- S. F. Rangwala & Co., Sahakar chambers, National highway road, Mehsana industrial estate, Opp. Pasabhai petrol pump, Mehsana-384002, Mo. :- +919825287918
- Maniar Sales, Meera chambers, Kadiakui, Relief road, Ahmadabad-380001, Ph. No. :- (079) 2213366
- Chamunda Machinery Store, G-5, Poojan Complex, Modhera road, Mehsana industrial Estate, Opp. Petrol pump, Mehsana-384002, Mo. :- +919824160793
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