Stair Climber
ME 423
Machine Design
Team 7 - Stair Climber

Guide : Prof. Ramesh Singh

Motivation and Market Need

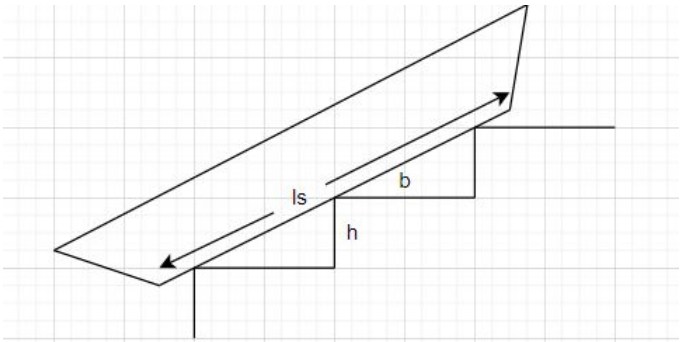
- Manual labour faces a problem in lifting heavy loads in staircases not having lifts or escalator on daily basis.
- It reduces their efficiency as they faces injury and can't work beyond a limit and the work is extremely exhausting.
- For specially-abled and old people, it's extremely difficult and risky to lift in stairs even when there is human support available.
- India has over 2 million low wage labourer, who lift heavy weights.
- And 26.8 million disabled out of which 21 million need wheelchair.
- There are 104 million old age people, who potentially need the solution.

Calculations

The model staircase has parameters b is in range 14-16 cm while h is in 7-8 cm.

It constraints base length of vehicle as, $l_s \geq 2\sqrt{b^2 + h^2}$

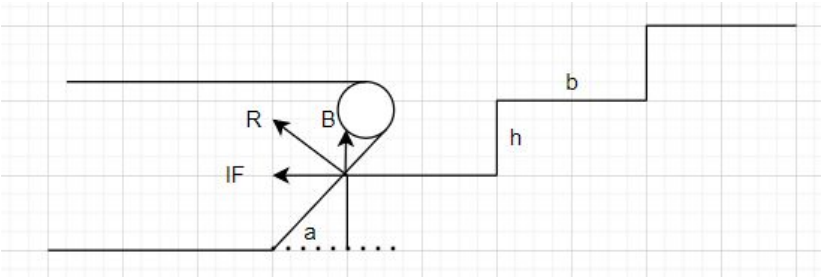
This gives l_s in range of 31-36 cm. As we want symmetric square base the width is also equal to 31-36 cm.



Calculations

Now as vehicle approach the first step, there is a reaction force applied on belt. One component of reaction force is headon impact force and other is force again gravity which helps vehicle to climb. The value of these forces depends on inclination angle of belt.

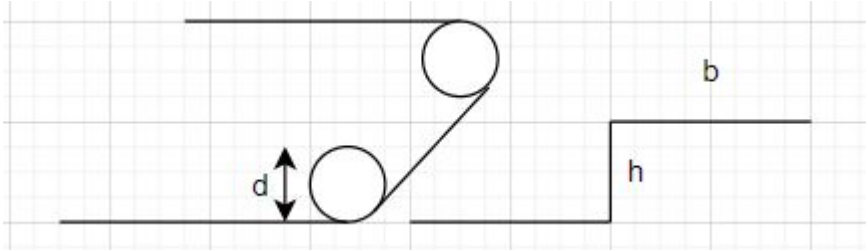
If it is too low than impact force will be higher and if it is too high and force against gravity is high and chances of vehicle toppling increase. Here we took 45 degrees to divide reaction force into equal parts.



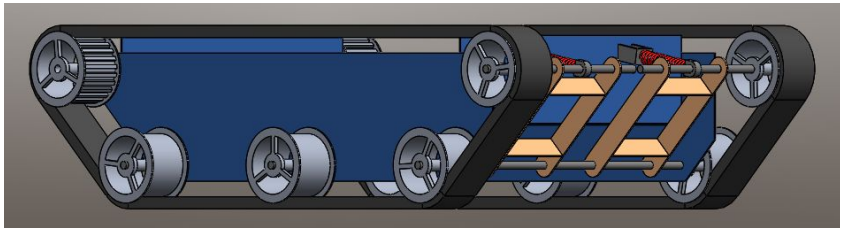
Calculation

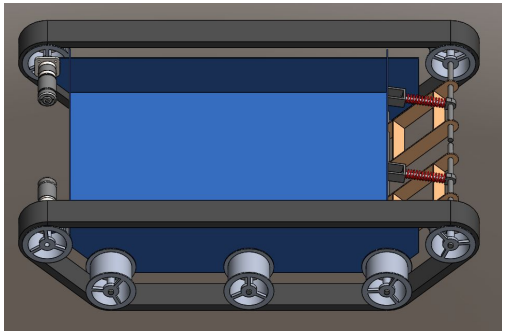
Here, overall height of vehicle should be greater than step size, which is for now 14 cm. Wheels diameter is around 6 cm which is lesser than step height (7 cm).

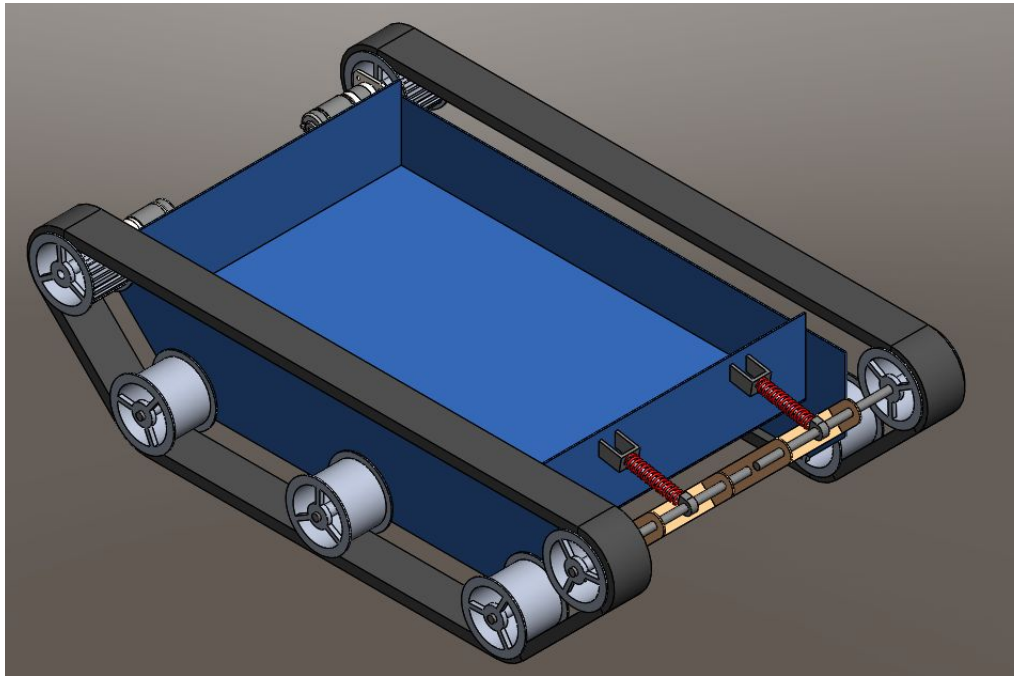
As we got vehicle height, base length and inclination angle of vehicle we got total length of vehicle 54-55 cm

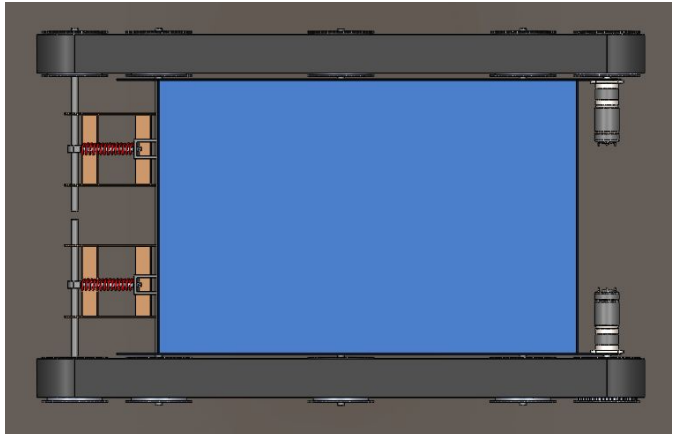


CAD









Material for Axles and Supporting body

Material Index : $M1 = \frac{E^{\frac{1}{2}}}{\rho}$, $M2 = \frac{\sigma^{\frac{2}{3}}}{\rho}$

Material Index per unit cost per Kg

Material	M1 (GPa^½)/(kg/m^3)	M2(MPa^⅔)/(kg/m^3)	Comment
Titanium	5.48	52.8	Too Expensive
Steel	14	45	Can support bending and tension allowing greater freedom of shape
Cast Iron	17	90	

Therefore best material to choose for our axles and body will be of cast iron.

Material for Conveyor Belt

Material Index : $M1 = \sigma^2/E\rho$

Material Index

Material	M1 (J/kg*10^-6)	Comment
Kevlar	0.35	Too Expensive
Polyester	0.02	Temperature sensitive
Styrene-Butadiene Polyisoprene	0.74	
Natural Rubber	0.48	High loss factor

Therefore best material to choose for our suspension spring will be Styrene Butadiene Polyisoprene also known as synthetic Rubber.

Material for suspension spring

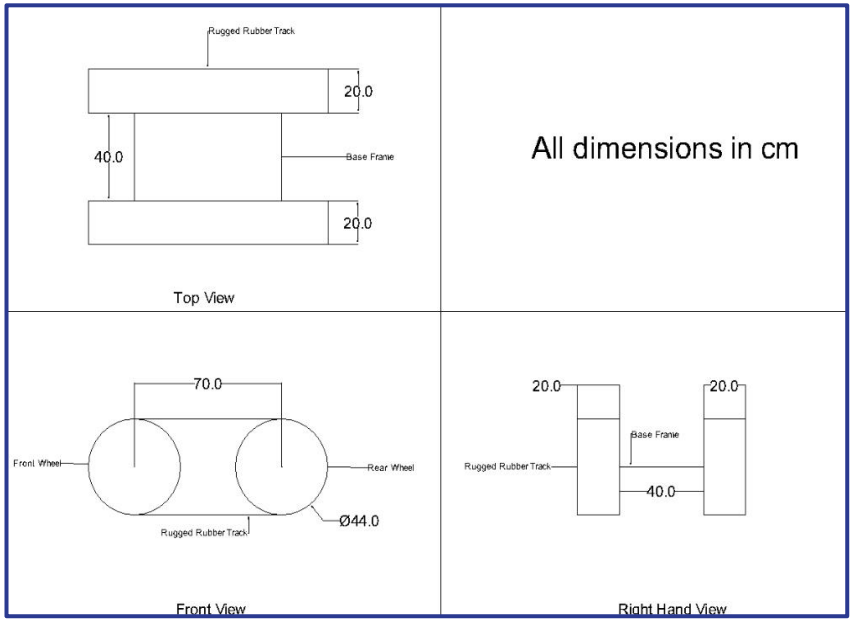
Material Index : $M1 = \sigma^2/E$

Material Index

Material	M1 (MJ/m^3)	Comment
Titanium-Alloy	4-12	Too Expensive
CFRP	6-10	Expensive
Spring Steel	3-7	Durable and low loss factor
Rubber	20-50	High Loss Factor

Therefore best material to choose for our suspension spring will be Spring steel.

Drawings


Rugged Rubber Track
20.0
40.0
Base Frame
20.0
Top View
All dimensions in cm
70.0
Front Wheel
Rear Wheel
Rugged Rubber Track
Ø44.0
Front View
20.0
20.0
Base Frame
Rugged Rubber Track
40.0
Right Hand View

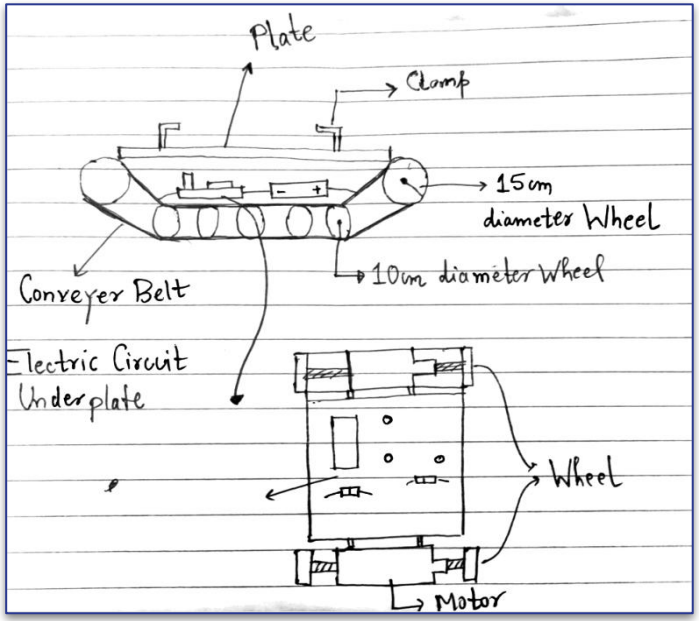


Plate
Clamp
15cm
diameter Wheel
10cm diameter Wheel
Conveyer Belt
Electric Circuit
Underplate
Wheel
Motor

Calculations

- The machine must be able to transport a load upstairs and downstairs with the aid of an user friendly controller.
- The machine must not skid/topple during the ascent & descent.
- When carrying the load, the machine must not deform/fracture.
- Machine should have a mechanical setup which can hold all kinds of loads & wheelchair.

Design Specifications

- Design Load - 1 kg
- Length of system - 540 mm
- Diameter of Wheels - 60 mm
- Width of system - 330 mm
- Parts - Conveyor Track, Wheels, Motors, Battery, Base Frame, Bearings etc.

References

Analysis of Stairs-Climbing Ability for a Tracked Reconfigurable Modular Robot

Mechanical Design for Track Robot Climbing Stairs | Semantic Scholar

Design & Fabrication of Staircase Climbing Wheelchair using Conveyor Belt Mechanism

Methodology

•Literature Review: Study the existing solutions and research done in this domain.

•Analyse, evaluate, improvise: Effectiveness of options.

•Determination of basic parameters of the complete system.

•Designing all the systems required for the the motorised system considering the objectives, preparing a solid model and preparing bill of materials.

•To identify the prospective vendors & manufactures and procure /manufacture all the components & assemble them.

•To develop testing method and to ensure the safety and appropriate performance of the vehicle

Thank you!

Have a nice day!