

Quadracycle

Design project II

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Introduction

To design and develop a human powered Qudracycle capable of carrying four people.

Idea behind the project is to bring out a sustainable mobility solution, which brings people together (sociable)

Qudracycle

Four-wheeled human-powered land vehicle

Sustainable transport

Human powered mobility comes as an **ideal** sustainable transport solution and probably the most challenging .

Sociable

The vehicle can act as a platform to bring people together ,providing an opportunity to make ride interesting and interactive.

Overview

of design process

Stage -1

- The design process starts with the study of history and then moving on to examples relevant in today's world.
- Indian cycle industry is studied to understand the market and current trend .
- Various scenarios having relevance to the concept of pedaling together has been identified from the Indian context and discussed.
- Technical study into frame suspension and steering has been done with latest innovation in materials and technology.
- Scenarios of interest has been identified and analyzed for design directions with insights from user study.
- With the help of design directions ,a design brief is concluded.

Stage-2

Ideation
concept development.

Stage-3

Detailed design
Cad model
1:3 scale model

History

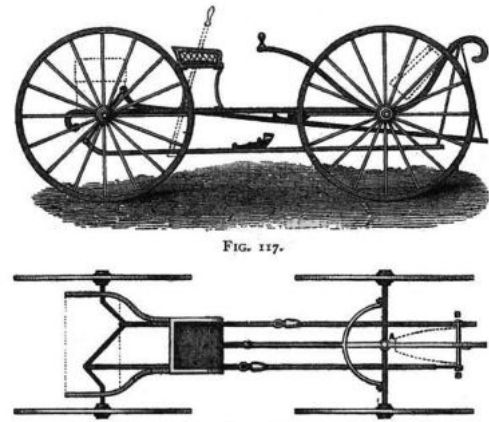
First Pedal-powered quadracycle was exhibited in 1853 at the Exhibition of the Industry of All Nations World's Fair held in New York.

Andrews Quadracycle

1869

built by Andrews of Dublin, Ireland.

Made from one inch-square iron and was propelled with foot levers that moved in a long horizontal ellipse.



The Sawyer Quadracycle

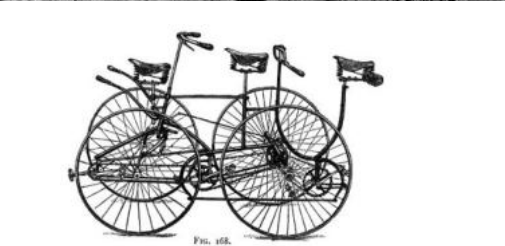
1855 Like the Andrews Quadracycle it was moved by foot levers driving the rear axle.

History



1885 Coventry Rotary Quadracycle

The Coventry Rotary Quadracycle was introduced in 1885



Rudge

The Rudge Quadracycle of **1888** is described as the first modern practical four-wheeler.



Velocar

Velocar - velomobiles made in the 1930s and 40s by Mochet et Cie of Puteaux, France.

Tubular-steel chassis with bicycle-sized wheels, variable gears and aerodynamic body.

Demand for velocar rapidly increased when petrol became unobtainable during WW-2, 1939-1945.

Seating



[IR-1]

Tandem (In line seating)

- In tandem seating the length of Quadra cycle is observed to be large.
- Lacks face to face interaction while on the move.
- Larger length demands larger turning radius.



[IR-2]

Sociable (side-by-side)

- As name suggests this configuration offers better interaction between passengers on the move.
- Shorter in length but wider.
- Very popular as surreys in tourist destinations abroad.

Existing models



[IR-2]

Tourist destination rental

Surreys

Open seating for two or more riders in a sociable configuration.

Designed to look like early 20th century automobiles with a bench seat, rack-and-pinion steering, and canopy top.



[IR-3]

Mountain quadracycles

Some quadracycles are designed to be the four-wheel counterparts of mountain bicycles and are optimized for strength and the ability to deal with steep and rough terrain.

All are single seat designs.

Existing models



[IR-4]

Touring

Constructed for the personal ownership Seats one person or two people in side-by-side seating and feature independent pedalling and gear selection.

They can have up to 192 gears,giving them remarkable hill-climbing capabilities.

Features

- Comfortable to ride.
- Can navigate steeper hills.
- Deals with crosswinds .
- Can carry much heavier load than a bicycle.

Existing models



[IR-5]

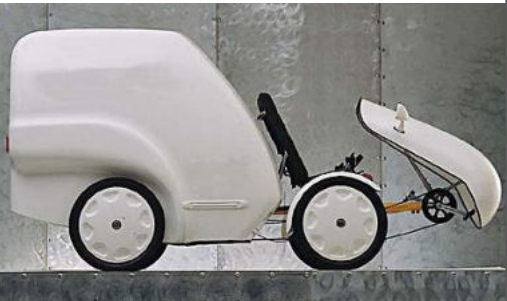
Racing

Pedal Car Racing can be found in many parts of the world.

UK, France and Italy have pedal car races.

Hong Kong has a 24-hour race every year.

Racing pedal cars are lightweight machines built for the sole purpose of racing and are therefore unsuitable for road use.



[IR-6]

Industrial use

Designed for local delivery of goods, such as spare parts in a factory environment or laundry at spread-out complexes. Have two seats and a pickup box or flat bed

Military applications, such as light logistics transport.

Existing models



[IR-7]

Toyota RLV concept

The Renewable Lifestyle Vehicle is only a concept vehicle. Has a hybrid, split power train solution of pedal power for stuck in traffic speeds and an electric mode for faster travel. Bio plastic, bamboo and aluminium create the panelling and cockpit.



[IR-8]

Pedal taxi

These tend to be four or even six seater and are used as taxis, pedalled by professional drivers. Tourist attractions and in the downtown areas of tourist destination cities.

Trend



India is the **2nd** largest manufacturer of bicycles in the world producing about **15 million** bicycles annually. Out of this, **3 million** are exported annually, which indicates a huge demand in the domestic market.

The premium/high-end bicycles segment is growing at **24-28%** .

Indian middle class / upper middle class are getting more and more selective, quality conscious and fitness conscious.

The annual domestic demand of bicycles in India is approximately 15 million units out of which around **2.5** million units is **government demand** for the various welfare schemes.

Pedaling together

Study of various possible scenarios for human powered mobility

Access to schools for girls

Fitness and leisure for family

Campus mobility

Spread out complexes

Fitness enthusiasts

Women cyclists

Pedaling together

Scenario- 1

Access to schools for girls



According to the **Saraswati Cycle Yojna** launched in 2004-05, free cycles are distributed to **Scheduled Caste, Scheduled Tribe girls** when they reach Class IX. In 2007-08, **OBC and BPL general** category girls were included in the scheme.

In **Rural Bihar** the trip to school is long, expensive and dangerous for many.



Mukhyamantri Balika Cycle Yojna - project launched in 2009 gives schoolgirls 2,000 rupees to purchase a bicycle.

871,000 schoolgirls have taken to the saddle as a result of the scheme. The number of girls dropping out of school has fallen and the number of girls enrolling has risen from 160,000 in 2006-2007 to 490,000 by 2011.

Bicycle riding skill has been introduced by **national literacy mission** in 1990 in pudukottai ,Tamilnadu .

Pedaling together

Scenario- 2

For Fitness enthusiasts



A silent revolution is pedalling its way into city dwellers' lives.

As more **Indians living in cities take to cycling for reasons ranging from keeping fit, to general purpose, office commuting and leisure**, cycling clubs have come up all across the country. With an annual production of 15 million bicycles, India is the largest bicycle manufacturer in the world after China.

The Indian bicycle industry is pedalling ahead at full stream, thanks to **the high-end fancy segment that has grown by almost 50% over the past years**



Urban adults are also taking to cycling as a mode of **recreation and fitness**. The concept of cycling as an exercise is fast catching up in urban India and the reason most companies are looking at urban markets to drive sales. The demand is in metros and Tier I and II cities.

Pedaling together

Scenario- 3

Campus Mobility



[IR-12]

Educational institutes like IITB, IITM, IITG etc discourages students staying inside the campus for any mode of personal motorized transport.

In fact they are treated as green campus and are provided with electric or CNG powered vehicles.

Student uses cycle as a source of regular commute to classes and back. Some takes cycle out side the campus for shopping or other reasons.



[IR-13]

- Cyclists clubs are very active at many campus including IITB.
- These clubs have regular weekend rides .
- Students can be attracted to concept of Quadracycle with the experience of travelling together from hostel to class and back.
- Many faculty members and staffs also uses cycles.

Pedaling together

Scenario- 4

Cycling clubs



Cyclist.in has listed around 254 cycle groups in India.

The club member hits streets in early hours or during weekends as a source of fitness and leisure.

Cyclist Groups in Mumbai

Palm Beach Riders	90 members.
Borivalli Cyclists Association	35 members.
Mumbai Randonneurs	80 members.
Bandra Cycle Club	40 members.
Carter Road Cyclist	200 members.
Mumbikers	450 members
Malad West Bikers	19 as of now
Malad link road group	6 members
Night Bike Riders	250 members
Cycling for foodies	79 members
Goregaon Bikers	40 members.
Andheri, lokhandwala and Vile parle -	200 members .
Lakecity Pedalers	138 Members.
Mulund and Bhandup Riders	45 Members.

Pedaling together

Scenario- 5

Women cyclists

Mobility for equity

Sexual harassment in streets and on public transport is a common occurrence. Transport requirements and schedules of women are often more complex than those of men. Women often make shorter journeys, with multiple stops, so timing is crucial. Given their short trips requiring multiple stops, a bicycle could have been an ideal mode of travel for many women in the city. The bicycle can provide affordable mobility to the poor women.

Self-reliance and independence

An affordable common platform to travel, will encourage women to come together and to take up small business initiatives or jobs. Bringing them together for government recognised Self Employment Scheme in poorly developed parts of country, an affordable mobility can play important role.



Pedaling together

Scenario- 6



Women cyclists - health Issues

Professor Luc Baeyons, a gynaecologist with the Centre Hospitalier Universitaire Brugmen in Brussels, specializes in sports medicine, found that **numbness, skin infections, chronic swelling and lymphatic damage are common among female cyclists**

Body makes contact with the saddle at three points:

Points one and two near sit bones .

The third point is the soft-tissue between the legs. **Whereas sit bones are designed to withstand body weight and pressure**, the soft-tissue of genitalia is not so. During long rides, **the pressure exerted on soft-tissue can cause painful skin irritation and constrict blood flow.**

Common Problems

Vaginitis (crotchitis), bacterial infections and yeast infections are the most common vaginal problems that women cyclists encounters.



Pedaling together

Scenario- 7

Fitness and leisure for family

Cycling has been treated as an active life style abroad. The pictures shows family pedaling together. Cycling together can be a good source for leisure and fun with quality family bonding time.



[IR-18]



[IR-20]

Pedaling together

Scenario- 8



Infosys mysore campus
More than 5000 cycles in the campus



Rourkela Steel Plant

en.wikipedia.org/wiki/File:Rourkela_Steel_Plant.jpg

Spread out complexes

People movement in large power plants and industrial complexes with infrastructure and good roads seems to be an interesting scenario for Quadracycle.

Attractions

- Good infrastructure.
- Well defined routes and roads.
- Mass movement of people after shifts.
- Official movements internal movements.

Rourkela Steel Plant

Has won following awards and recognition for their initiative towards green drive.

- Greentech Environment Gold Award
- Srishti Good Green Governance Award for 2010
- National Energy Conservation Award (2nd Prize)

Human powered mobility can be an attractive move towards green drive by reducing motorized movement within the campus.

Pedaling together



Pedaling together in India

- Indians have been familiar to the idea of pedaling together but only at tourist destinations.
- The images are from tourist destination called OOTY. Boats which are pedaled by four or more are available for a duration of thirty minutes.
- Tourists are sure to carry back this experience of pedaling together.

Evaluation of scenarios

The scenarios are self evaluated from the perspective of Qudracycle for limitations and benefits with understanding from studies on the same,to shortlist the appealing scenarios .

Scenario	Limitations	Benefits
Access to schools for girls	<ul style="list-style-type: none"> •Poor infrastructure in rural areas •narrow and poor roads •Cycles have uses other than school rides, local movement. 	<ul style="list-style-type: none"> •Safety of travelling together for girls •Vehicle itself checks that students are going to school regularly , idea of pedaling together
Fitness and leisure for Family	<ul style="list-style-type: none"> •Only for weekend leisure/fitness rides •Limitations of clear and predictable routes in urban environment •Not practical in traffic 	<ul style="list-style-type: none"> •Residential complexes with good infrastructure makes sense. •Quality family time.
For fitness enthusiasts	<ul style="list-style-type: none"> •Makes sense only for a small group rather than an individual. 	<ul style="list-style-type: none"> •Workouts becomes involving •Feeling of being together
Campus mobility	<ul style="list-style-type: none"> •Parking problem both in length and width. •Time of day when Quadracycle is really useful 	<ul style="list-style-type: none"> • Health of students •Drive towards true green campus
Cycling clubs	<ul style="list-style-type: none"> •Space for storage 	<ul style="list-style-type: none"> •Dedicated cyclists are available •Can be owned by clubs
Women cyclists	<ul style="list-style-type: none"> •Less practical in urban scenario 	<ul style="list-style-type: none"> •Seating position can be relaxed •Cloths no barrier •No cycle balance required •Feeling of safety and togetherness
Spread out complexes	<ul style="list-style-type: none"> •Status issues 	<ul style="list-style-type: none"> •People movement after shifts makes sense •Internal official transport •Sustainable transport initiatives are encouraged.

Pedaling In IITB

View from campus

Prof. Sanjeev Chaudhari
CESE

Why cycle?

Like to do so ,health benefits

By the act of doing I am setting an example.

Prof. Om Dhamani
CSE department

Why cycle?

Campus small enough for cycle, good for environment.

Encourages kids and students to use cycle.

Prof. Sadhu
IDC

Why cycle?

Convenient ,no fuel needed ,Rarely travels out of campus .

Encourages his daughters to use.

Views on Quadracycle -

- We don't have such a culture.
- My family old enough to pedal together.
- Though prefer a cycle for two pedaling together-tandem or side by side.
- Issues about parking as it is always compared with cycle.

Views on Quadracycle -

- Seems good idea ,but roads needs to be flat.
- IIT has very steep terrain especially towards hill side.
- Looks like a vehicle for fun and leisure.
- I would like to take a ride with my family and kids.

Views on Quadracycle -

- Vehicle should not roll back on hills.
- Two people travelling together-look for young couples.
- Why a device for two and have an attachment for four.
- How will four people pedaling together be matched.?
- Limit of human power nowadays, look out for weight.

Pedaling in BARC



BARC is India's premier nuclear research facility based in Trombay, Mumbai

Office Buildings are 3km away from the gate for security reasons.

Employees reach gate by their vehicle or by walk. Beyond the gate only cycles are allowed.

Employees without cycle wait for the bus or walk. Buses are crowded during morning and evening shifts.

Around 7000-8000 staffs and about 2000 contract workers travel in and out every day.

Huge line of cars before the gate during office hours.

These pictures are from residential area of BARC.

Good infrastructure, well maintained roads are the prime attractions of the campus from mobility point.

View from BARC

Anil Kumar

Why cycle?

Cheap ,less maintenance and good for health

Kailash Gharat

Why cycle?

- Health conscious,all amenities are making you weaker ,I cannot buy health .
- Encourage wife and kids to pedal and jog.
- First purchased car ,then scooter and finally three cycles.

Views on Qudracycle -

- Status issues on travelling with family as it seems to picture cycle rickshaws in Indian roads.
- Space occupied on road and for parking.
- For tall rise building every family has a two wheeler and four wheeler.
- Interested in foldable cycle his neighbor has.
- Can afford to buy thing but unable to buy space.

Views on Qudracycle

- Has seen examples before ,interesting concept.
- People walking parallel won t take much space as compared to two cycle or a Qudracycle.
- Safety should be given high priority-lights reflectors.
- Where will parents and kids sits and who will steer it?
- To look at pedaled baby stroller.

Pedaling together

How is it like pedaling together

Aryan
Mridul
Mehul
Darsh
Vatsal



- Meets every Saturday at Marine drive near Chaupati beach.
- Long stretch of 8 km along marine drive
- Also cycles to crosswords near Marine drive
- For **fun** and leisure.

Pedaling together



*Deepak Malani
Member of
IITB cycle club
Bandra cycling club
Lake city pedalers
Powai cycling*

- Group travel At lest 50Km round trip
- Group size 3-30 members
- Early morning rides
- 15-20 km travel speed
- Every 30min sip water
- **Tandem safe**
- **Sociable -risky in traffic.**

Why group ride

- Company
- feeling of being together and sharing together.



Clifford Liu's custom side-car to
Hercules Roadster.

Deepak shared a club member opinion on sociable seating- Both the occupants are able to see and share the same .

When riding,he gets motivated by other cyclists,and also non riders who are sits in vehicle with unhealthy figures.

Take on Qudracycle

Clear and familiar routes make sense.

Cannot match with the pace,a serious cyclist look for.

Pedaling together



Details of the ride

- IITB ,powai to Marine drive
- Round trip 60 Km
- Forward journey - 3 hrs
- Return journey- 3.5hrs
- **Cycles** - Firefox cyclone ,Firefox roadrunner.

Going there

The LBS road.
Ride through the traffic
Poor civic sense
Pedestrians causes more worries than vehicles
But there is fun negotiating space through vehicles, though risky.

Coming back

The Easter express way ride
Enough space to travel in parallel
Boring long tracks.
No issue with traffic

Observation by the group-

- Cycle ride the best for negotiating traffic and people.
- Quadracycle can be fun for early morning city rides, when traffic is minimum. Shorter and safe routes preferable.
- Quadracycle can offer fun of chatting and being together while pedaling.
- Each cyclist is a source constant motivation for others.

Inputs

After evaluating scenarios and other studies-

1. Qudracycle brings in the image of a medium speed vehicle which can offer a comfortable ride, leisure, fun and fitness.
2. The health issues with bicycle saddle can be addressed in Qudracycle, which offers opportunity to try out comfortable seating positions and also freedom of dress.
3. Space consumed on road and space required for parking a big concern.
4. Why always four seat, make for two and convert it to four when needed.
5. How it can tackle slop with the weight of four.
6. Power of four people has to be efficiently utilized.
7. Safety should be given high priority as the vehicle has four people on board.
8. How a family is accommodated in the vehicle, addressing all needs?

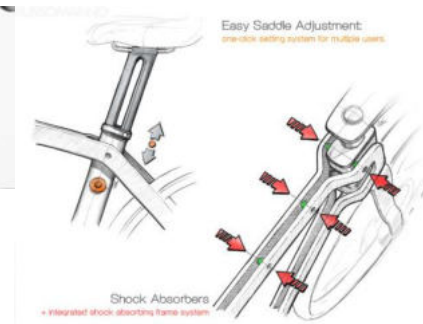
Technical study

Innovations in cycle frame

Sandwichbike bicycle



BKR concept bicycle



Technical study

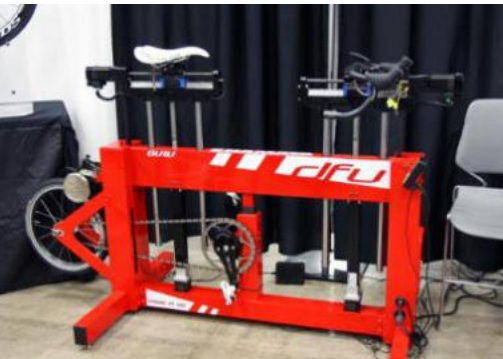
Innovations in cycle frame

Izhar Gafni's cardboard Bicycle

Izhar Gafni has built the first bicycle made almost entirely of cardboard. When Gafni begins mass production, his bikes should cost no more than \$20. They can last as long as ten years. It took him four years to figure out how to cancel out the corrugated cardboard's weak structural points. Now he requires no metal parts at all to make his cardboard cycles strong and durable.



Dynamic Fit Cycle



Active safety



The Hqvding

Swedish industrial designers Terese Alstin and Anna Haupt developed the Hqvding, a bike helmet that stays nearly invisible until activation. The device is disguised as a collar and is equipped with sensors that detect when an accident is imminent, upon which it inflates into an airbag that surrounds the head within 0.1 seconds.



Reelight

Patented battery-free light from Reelight.

Cyclists always have lights on their bicycles day and night.

Based on the electrodynamic induction principle and operates via two magnets mounted on the spokes with the light itself on the wheel hub.

Seating



Bicycle saddle

It performs a similar role as a horse's saddle, not bearing all the weight of the rider as the other contact points also take some of the load. Bicycle saddle has been associated with health problems especially in women riders.



Bicycle seat

The semi-reclined position of the recumbent bicycle seat provides a much broader distribution of the body weight across the more anatomically correct padded areas of the buttocks and across the back. The hands, arms and shoulders are in relaxed position without bearing the weight of torso. With the back in a reclined position, the abdomen is flat and straight allowing full and easy expansion of the lungs. The head in a neutral position, looking forward and the neck is relaxed. Better Eye contact in recumbent riding position.

Suspension

Qudracycle with double wishbone suspension



DW suspension uses two wishbone-shaped arms to locate the wheel. Each wishbone or arm has two mounting points to the chassis and one joint at the knuckle. The shock absorber and coil spring mount to the wishbones to control vertical movement, and camber angle.

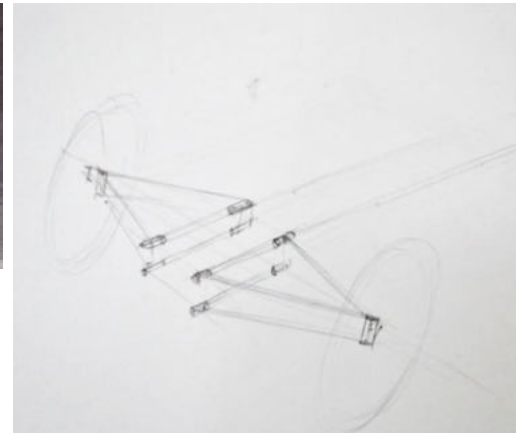
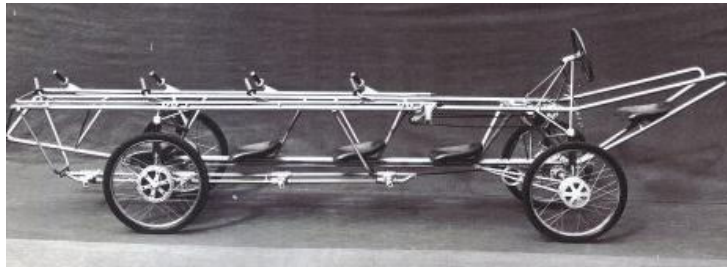
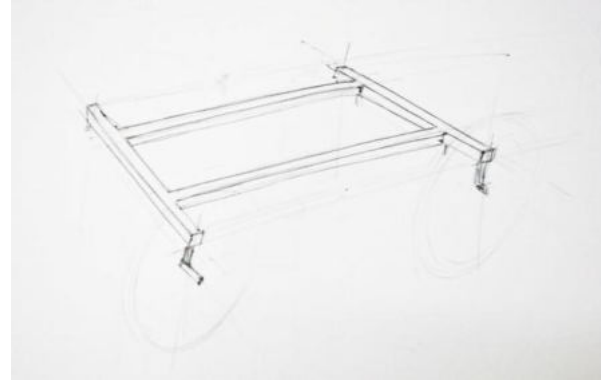


CARV X ALL-TERRAIN RECUMBENT QUADRICYCLE

Can tilt all 4 wheels by a special steering/tilting technique. This technique will provide a totally new way of riding a bicycle. The frame is completely build from aluminium, and has 4 independent double wishbone suspensions. Also has 4 hydraulic disc brakes, and the 14 speed hub.



Study of frame



Design brief

Intent

- To design and develop a compact and practical four seater Qudracycle.
- As a source of people movement and fitness in areas like spread out complexes .

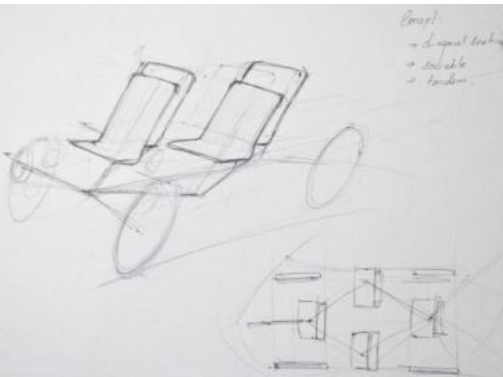
Technical

- Two seater to four seater. Exploring transformation of seating.
- Relaxed seating instead of saddle.
- Light weight construction.
- Minimal parking space.

Emotional

- Togetherness and joy as the strong emotion.
- Family

Initial ideations

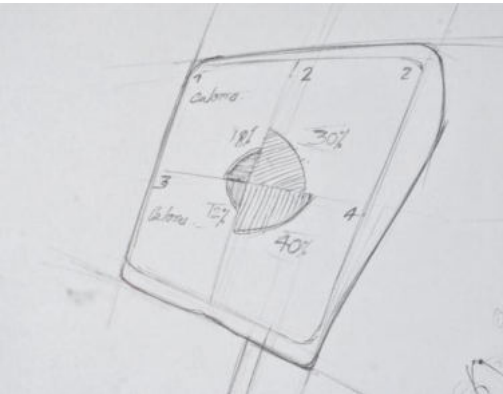


Seat layout

Tandem-sociable seating

Chassis with variable width ,for allowing various seat layouts.

In seating as shown in sketch ,last row passenger can make use of space between middle row seats for pedaling ,bringing down total vehicle length.



Interactive displays

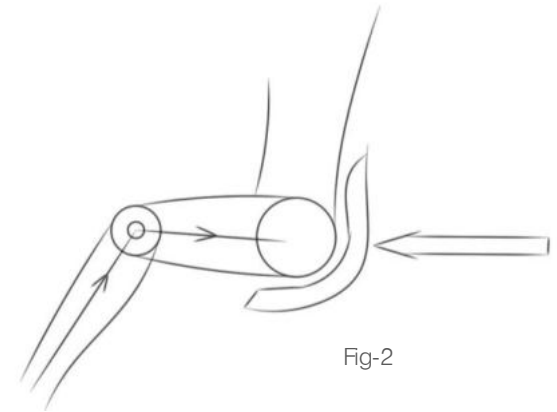
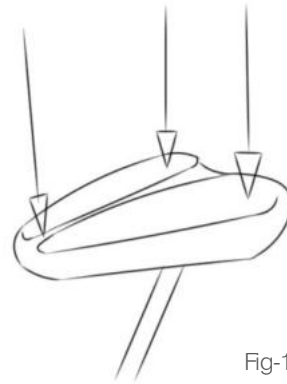
A Common display showing Calories burnt and energy input per rider.

It can be digital or analog showing input per rider.

This can enhance sporty spirits and motivate to keep up with other riders.

Initial ideations

Bicycle saddle



Choice of saddles for women cyclists are limited.

Figure-1 shows the three pressure points in a regular bicycle saddle.

- Health problems are sensitive enough to discourage women from pedaling as discussed in scenarios.

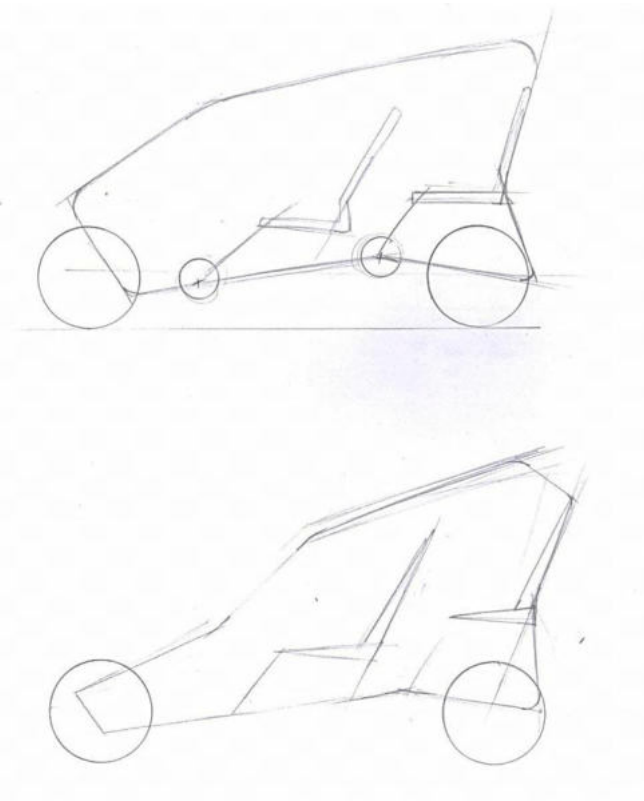
Quadracycle provides opportunity to try out comfortable seating positions other than saddle type.

Figure -2 shows an idea of bicycle seat which could offer better support and less irritation to sensitive parts, but this position calls for a different posture for pedaling.

These seating positions could allow enough degree of freedom of movement with a wide range of dress.

Sketches

These sketches are mostly based on existing layouts with a different silhouette



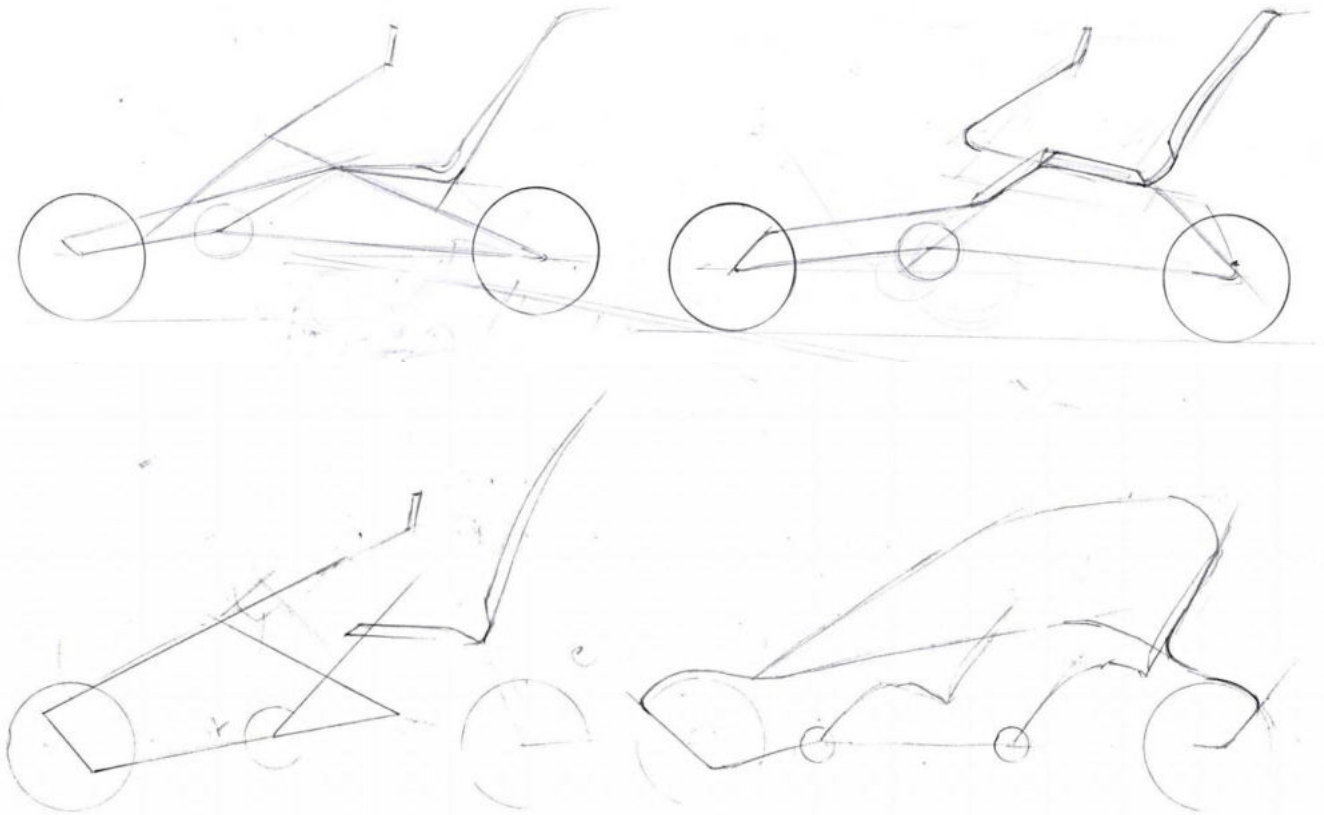
Hub center steering for front wheel



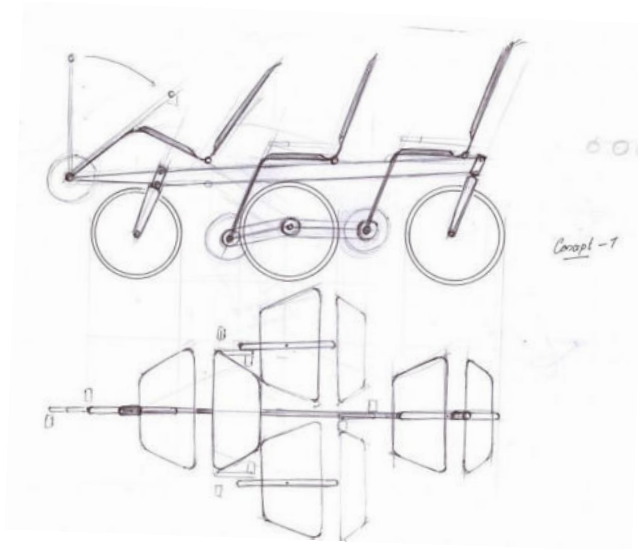
Rear wheel steer

Sketches

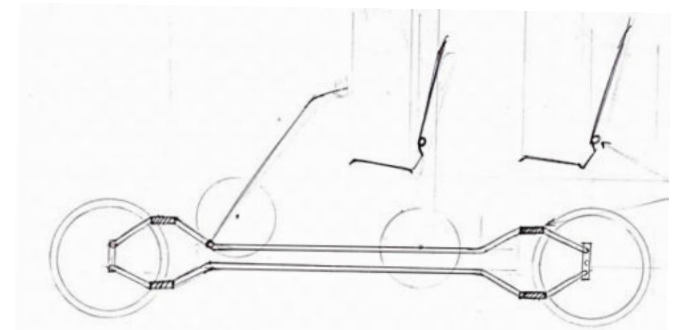
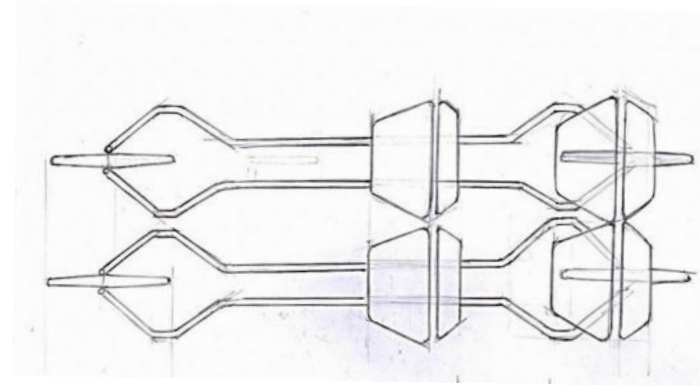
Two seater sporty layouts



Sketches



Three row seating with steer action in both front and rear wheels . Second row has two seats



Hub center steer for front wheel and has lower frame elements.

Concept development

1. Fixing dimensions

- Anthropometric dimensions
- Studies with standard cycles and different orientations.
- Dimensional comparison among existing examples.
- Fixing dimensional targets .

2. Different packaging ideas

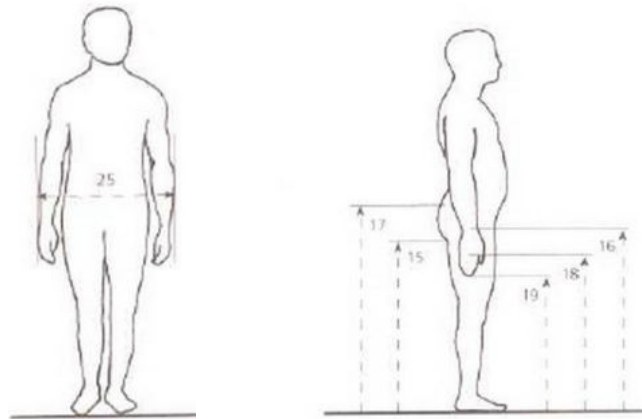
3. Steering, braking and Controls

4. Keywords

5. Concept development and iterations

Concept development

Anthropometric dimensions



25.Maximum body breadth, relaxed

	5th	50th	95th
Male	415	503	619
Female	391	469	599

15.Gluteal furrow The furrow formed between buttocks and the upper thigh muscles.

	5th	50th	95th
Male	682	767	841
Female	640	727	807

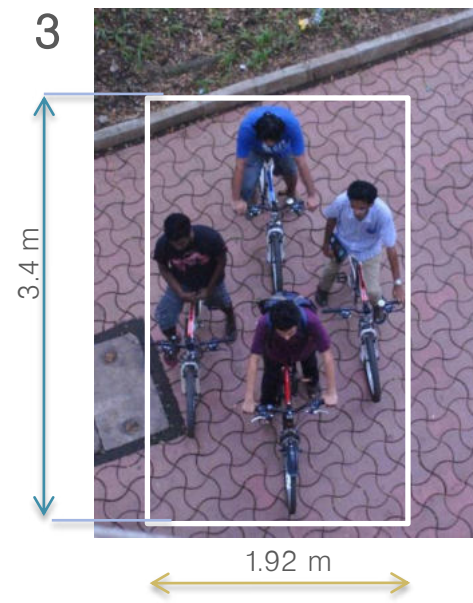
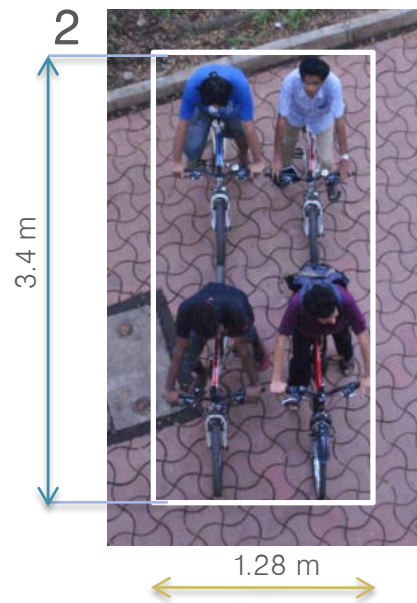
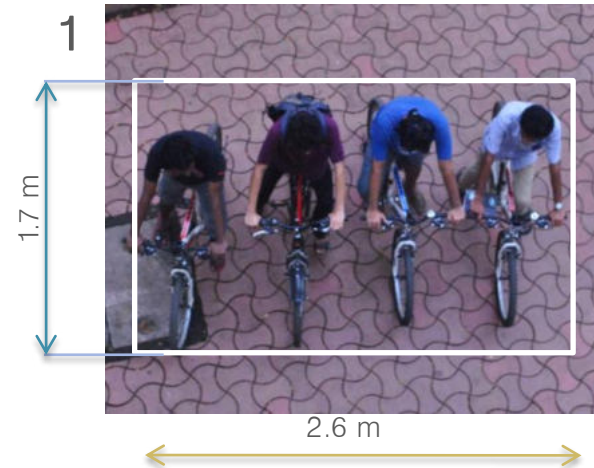
Maximum body breadth in relaxed state for 95th percentile Indian male is 619 mm .
The minimum width of Quadacycle with sociable seating should be $619\text{mm} \times 2 = 1238\text{mm}$.

For minimum seat height gluteal furrow for 5th percentile Indian male is considered.
The value is 640 mm.

If the seat is enable with height adjustability the maximum height to be addressed is 841mm,gluteal furrow for 95th percentile Indian male.

Concept development

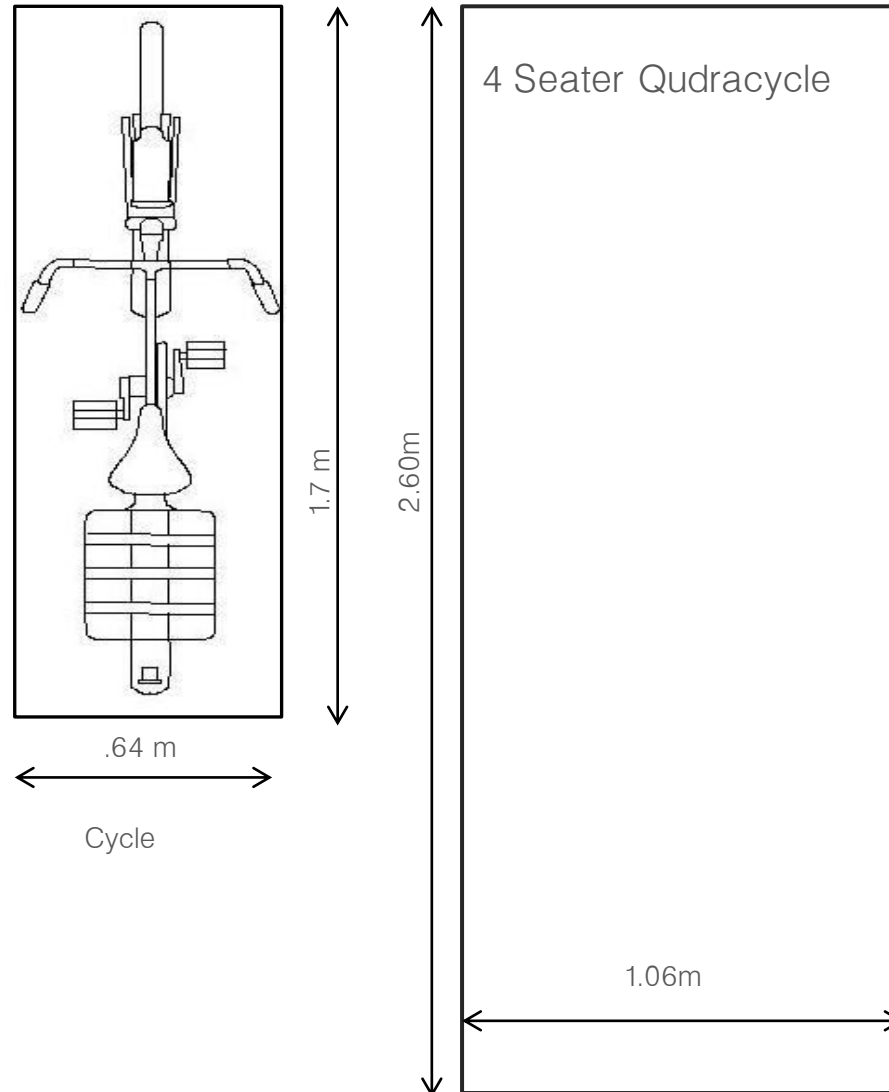
Studies with cycles



Inputs for packaging

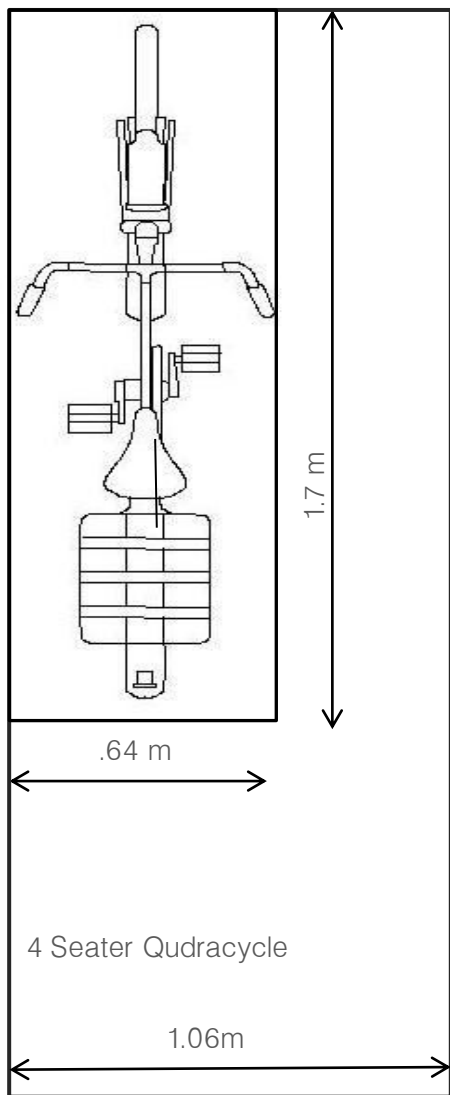
1. Joining 2 compact two seater cycles to make a complete Qudracycle.
2. A compact Qudracycle designed for two ,and can accommodate four when needed.
3. A Qudracycle transforming from two seater to four seater configuration with a proportional increase in width

Dimensional comparison

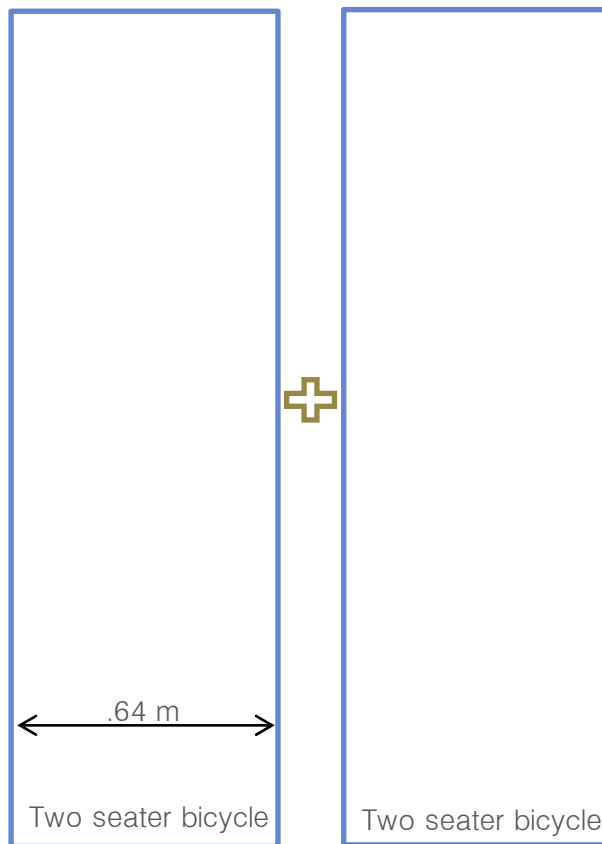


Length	2.6m
Width	1.06m
Weight	104kg

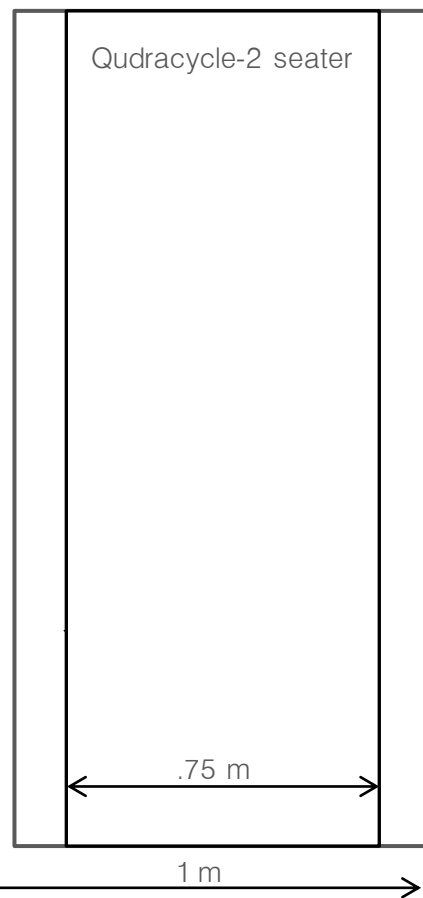
Dimensional targets



Two seater joined



2 seat- 4 seat transformation



Steering,braking and controls

Steering

Single person controlling.

Good visibility

If two cycles are joined,steering in one can be defeated .



Braking

Braking in all wheels

In case of joining,brakes are to be joined and controlled together .

Powerful enough to take weight of four with vehicle.



Drive

Pedaling power of all four to be effectively delivered to driving wheels.

Gears for each rider.

Differential drive for better traction on driving axle.



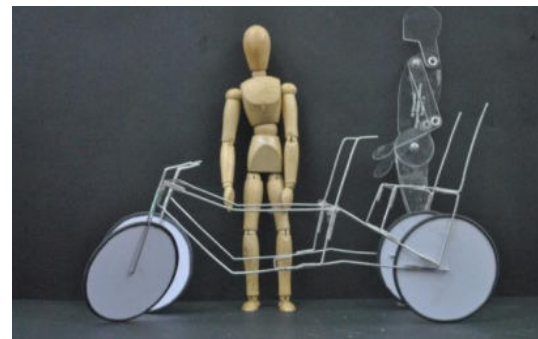
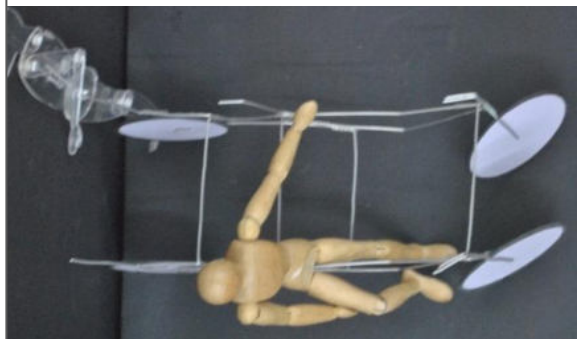
Controls

Easy control for attaching ,adjusting etc.



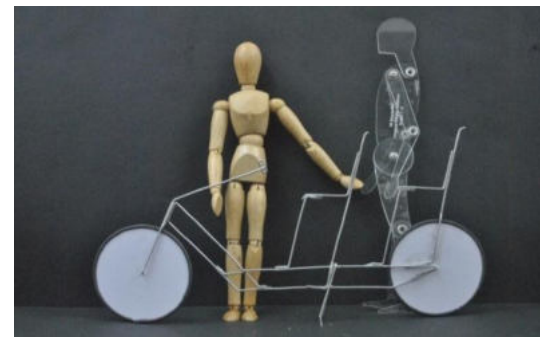
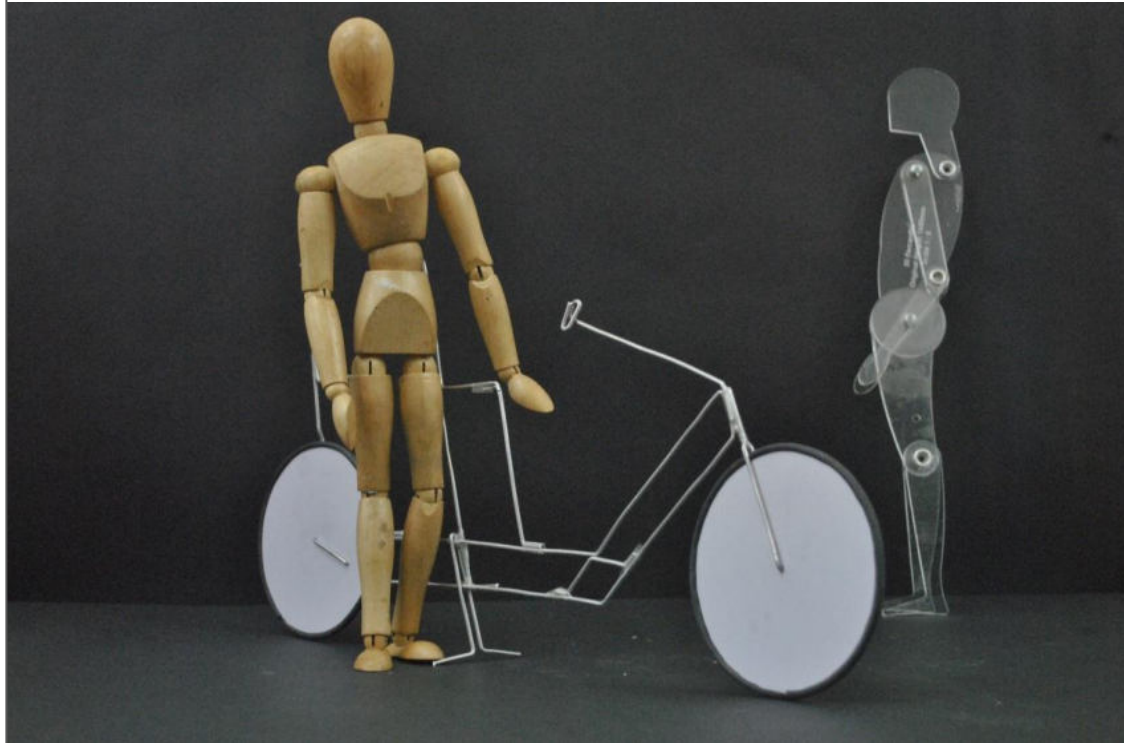
Concept-1

Iteration-1



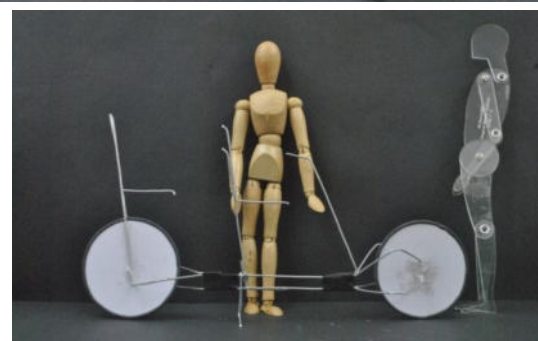
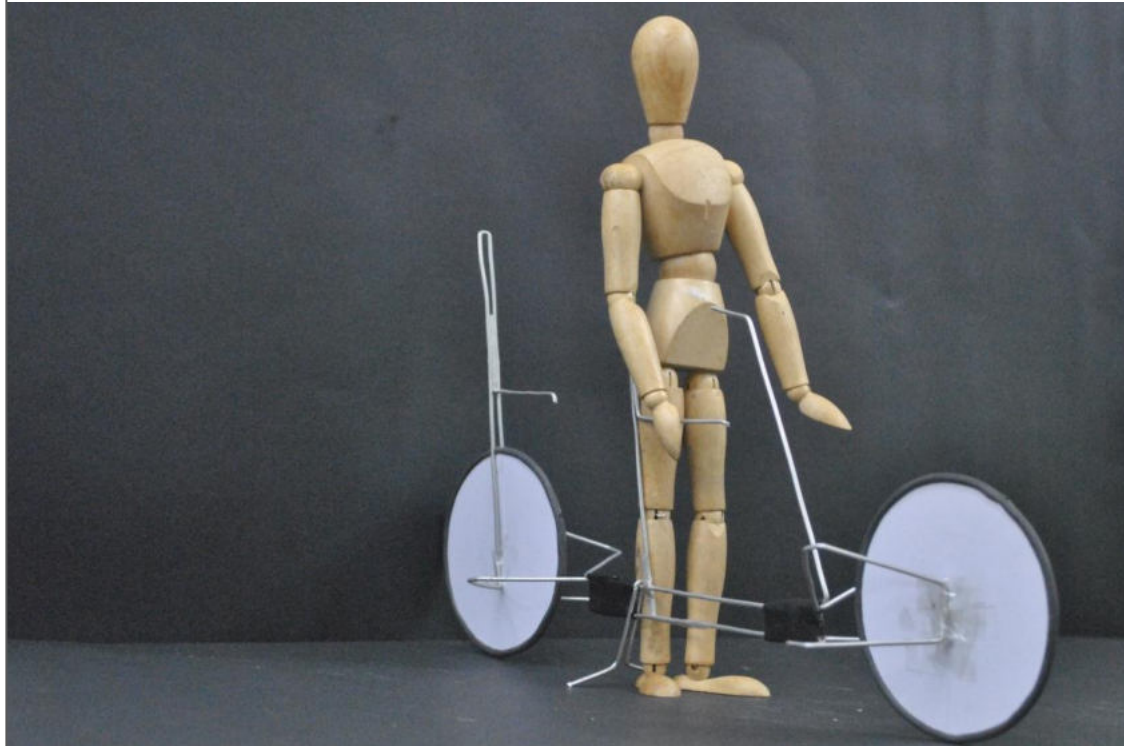
Concept-1

Iteration-2



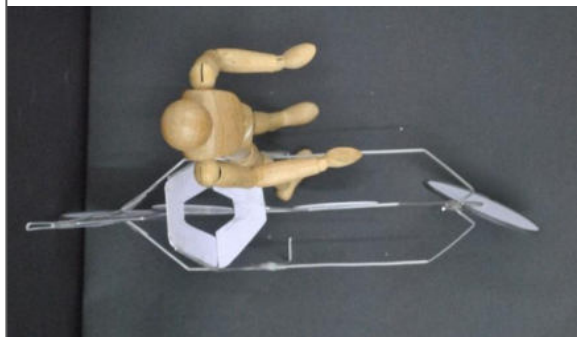
Concept-1

Iteration-3



Concept-1

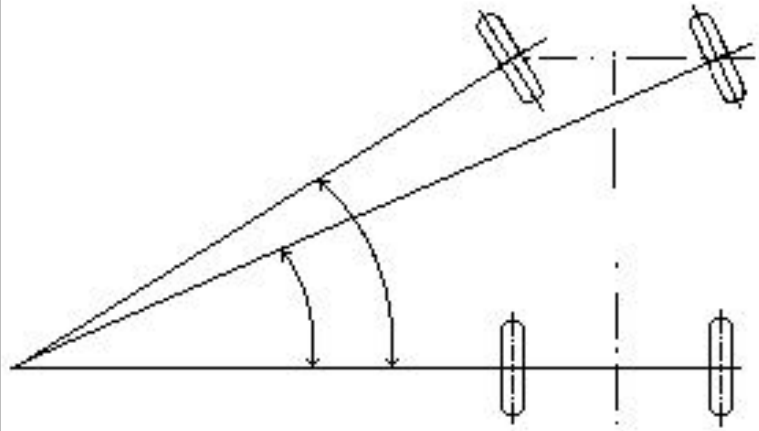
Iteration-4



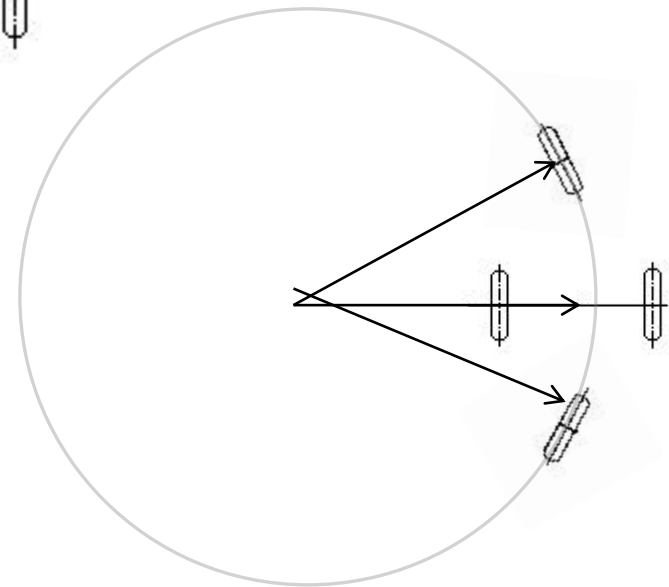
Concept-2

Steer principle

The **Ackerman concept** is to have all four wheels rolling around a common point during a turn. The intention of Ackermann geometry is to avoid the need for wheels to slip sideways when following the path around a curve

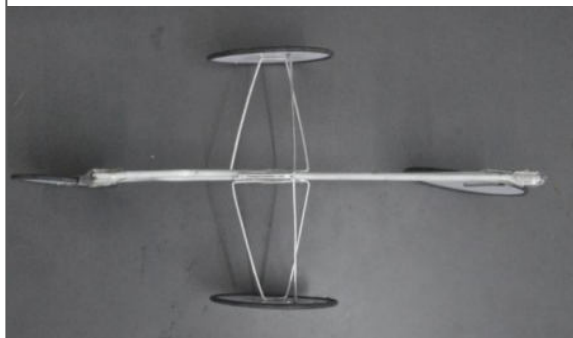
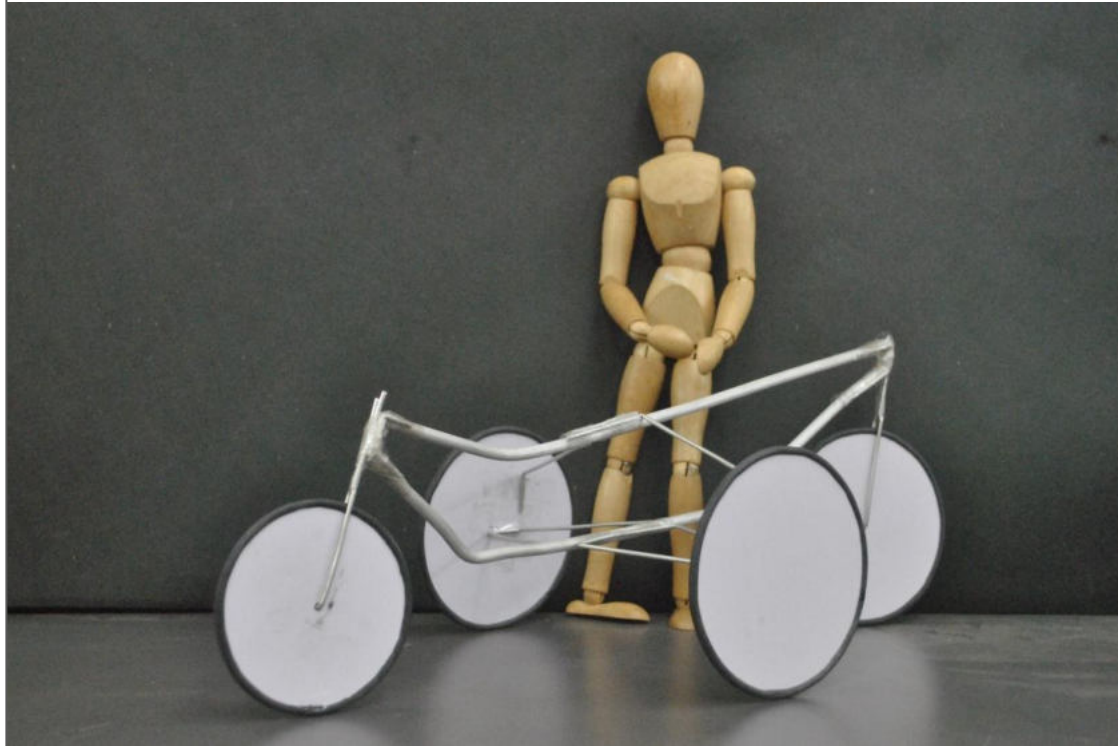


Pedal ambulance



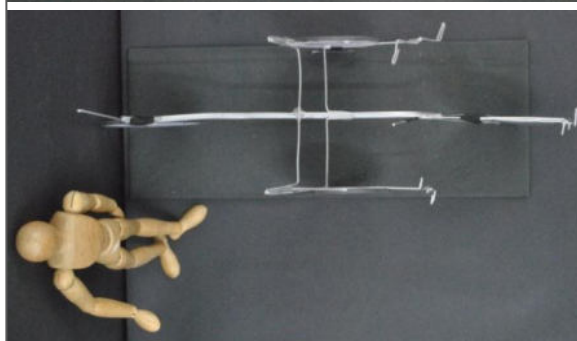
Concept-2

Iteration-1



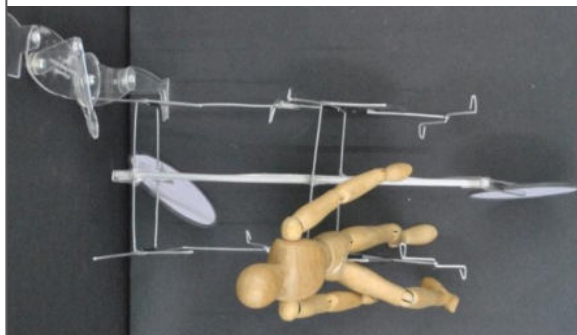
Concept-2

Iteration-2



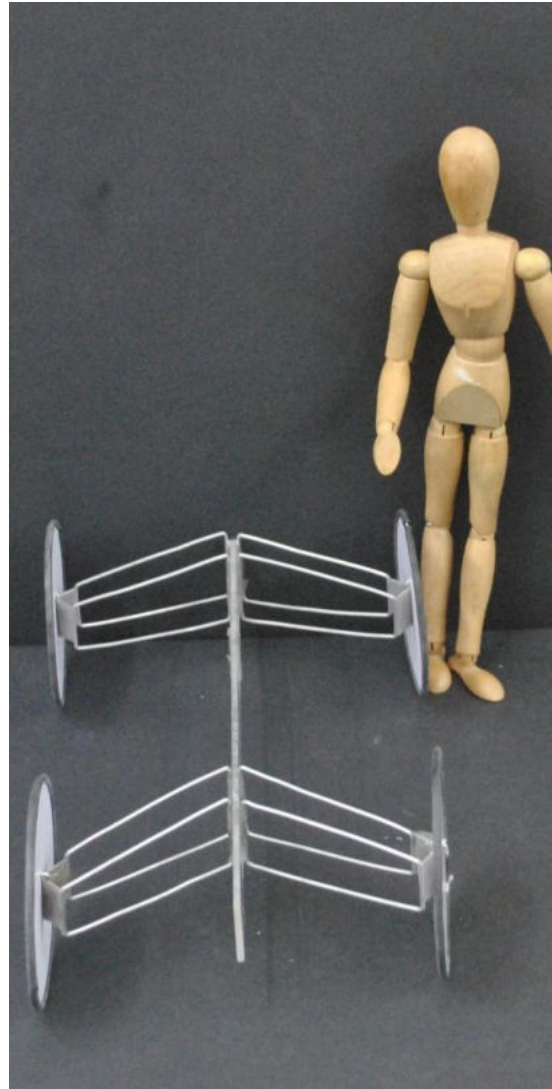
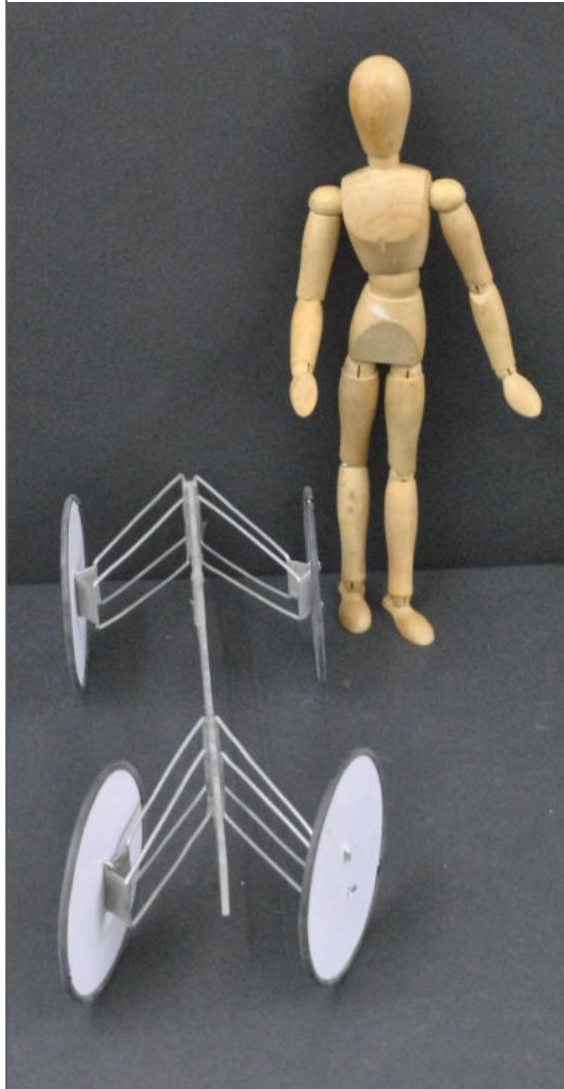
Concept-2

Iteration-3



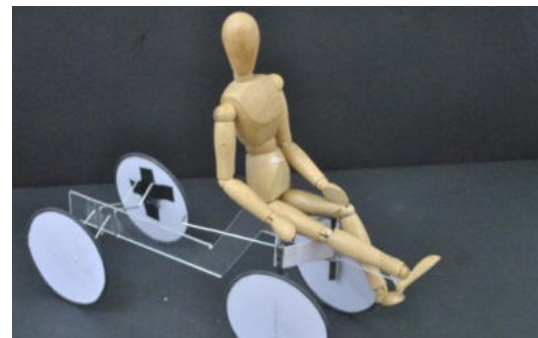
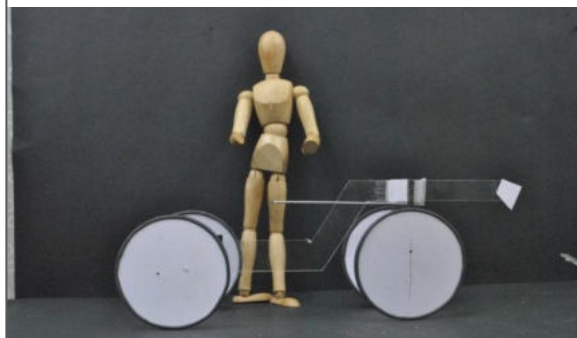
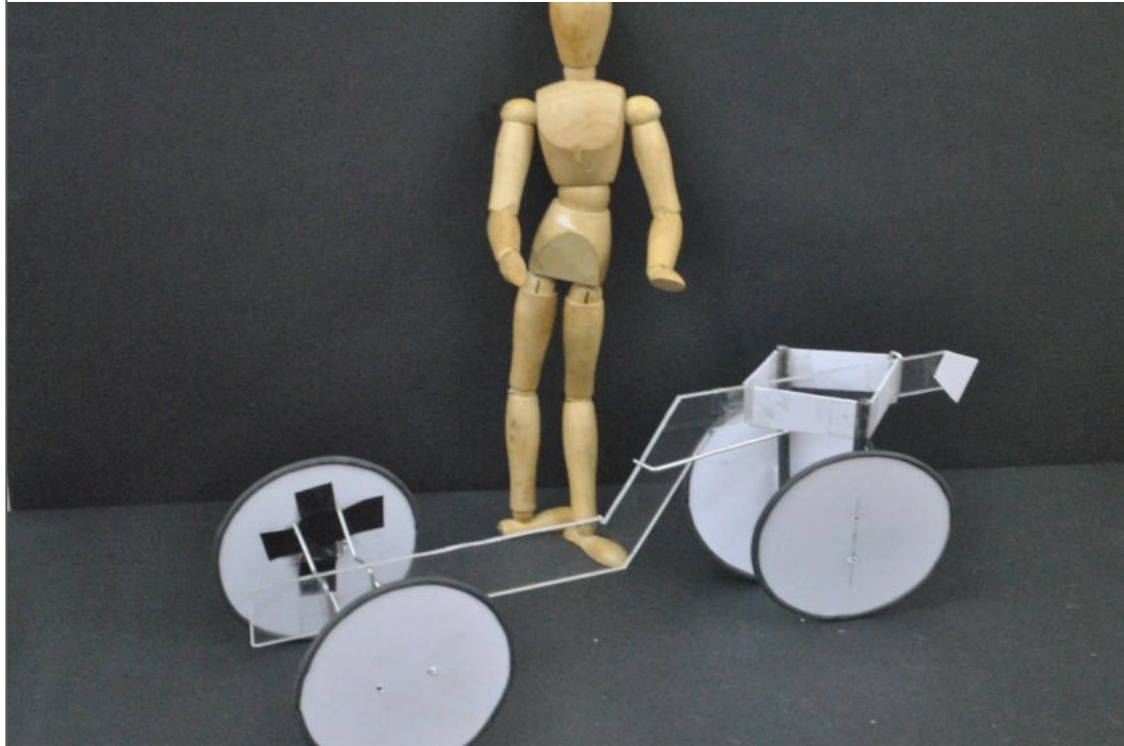
Concept-3

Iteration-1

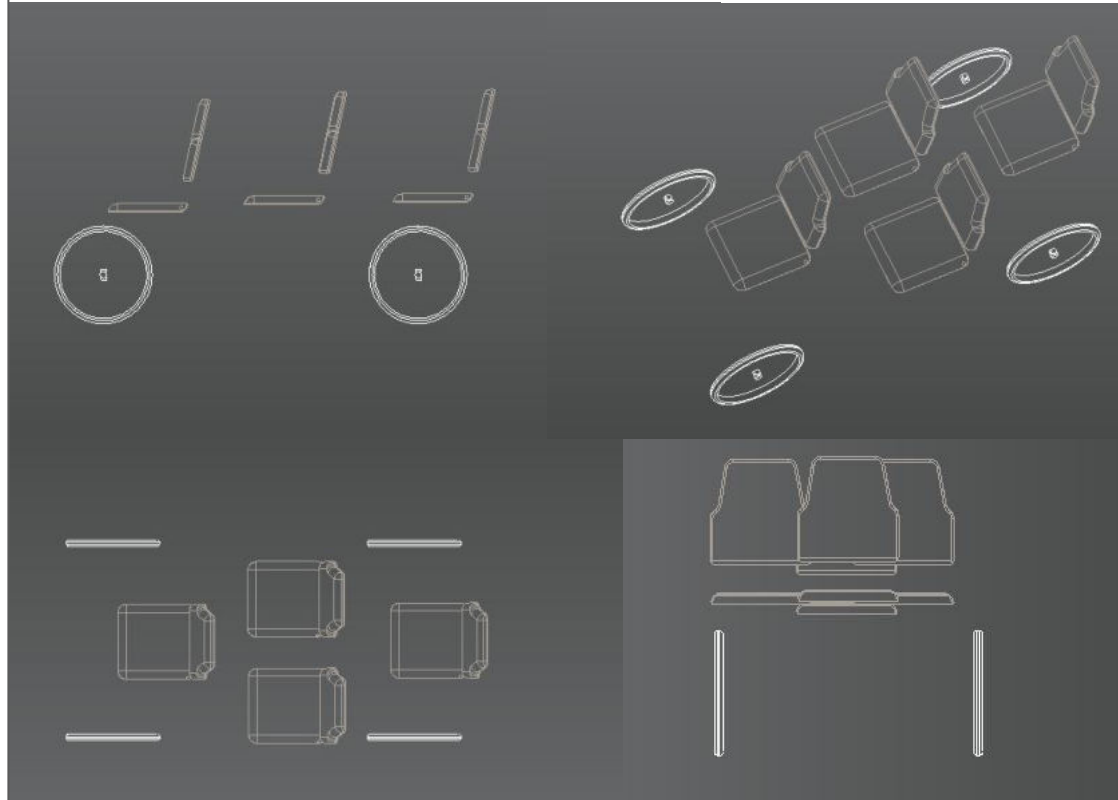


Concept-3

Iteration-2

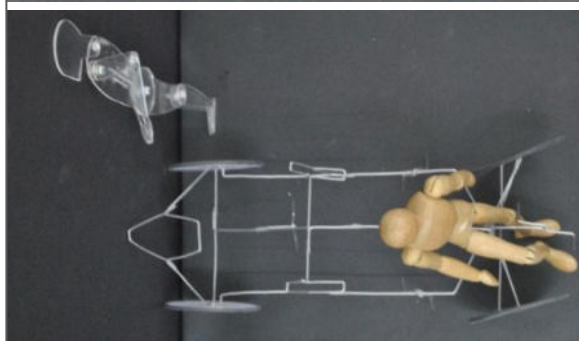
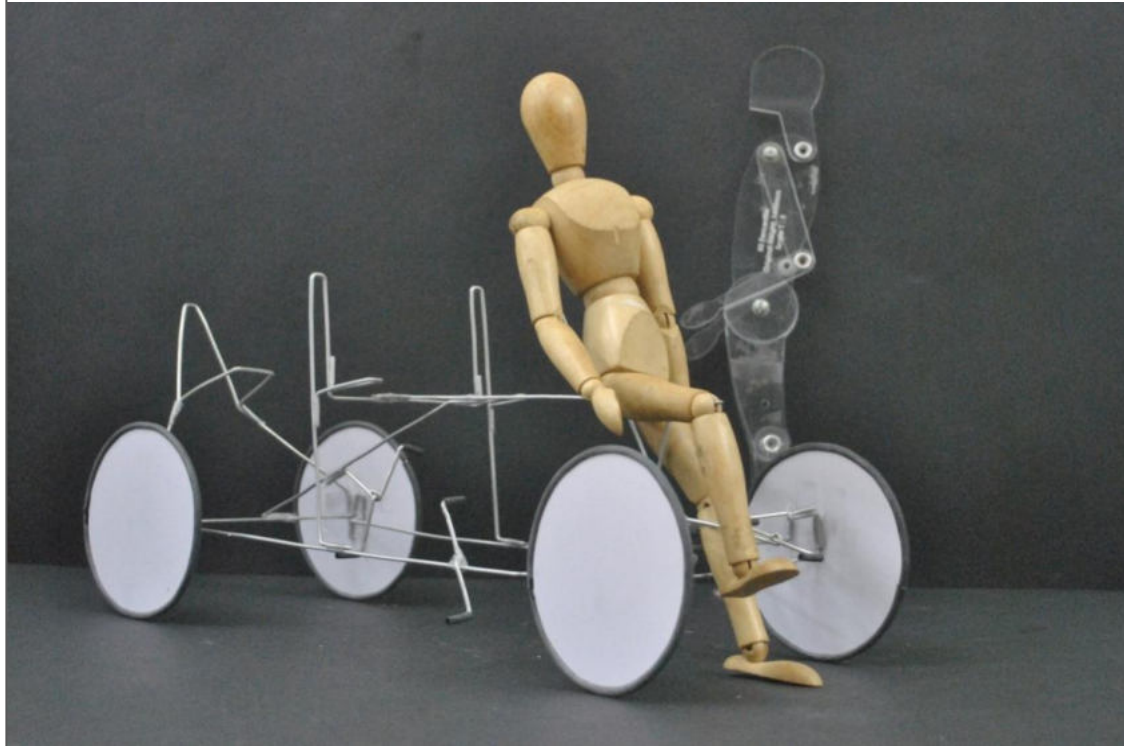


Concept-4




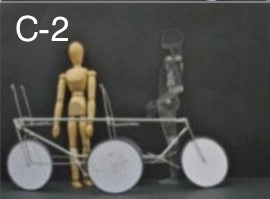
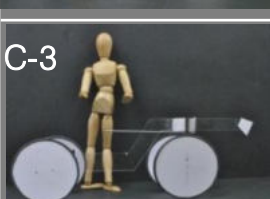
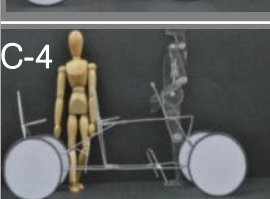
Concept-4

Iteration-1



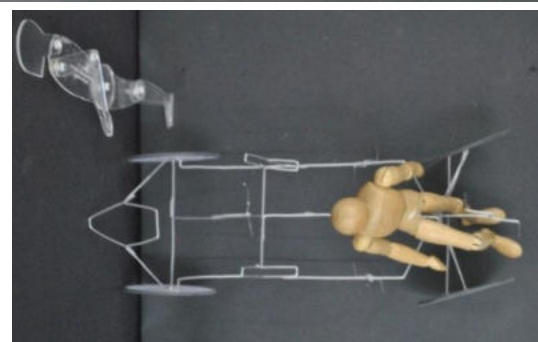
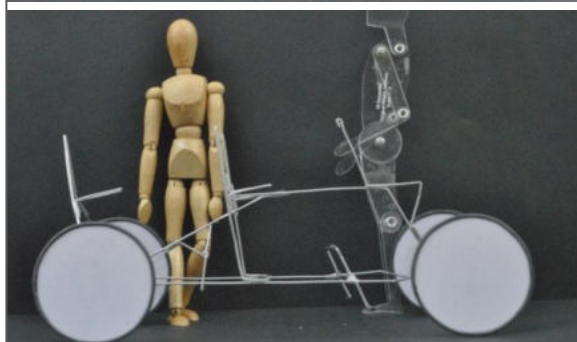
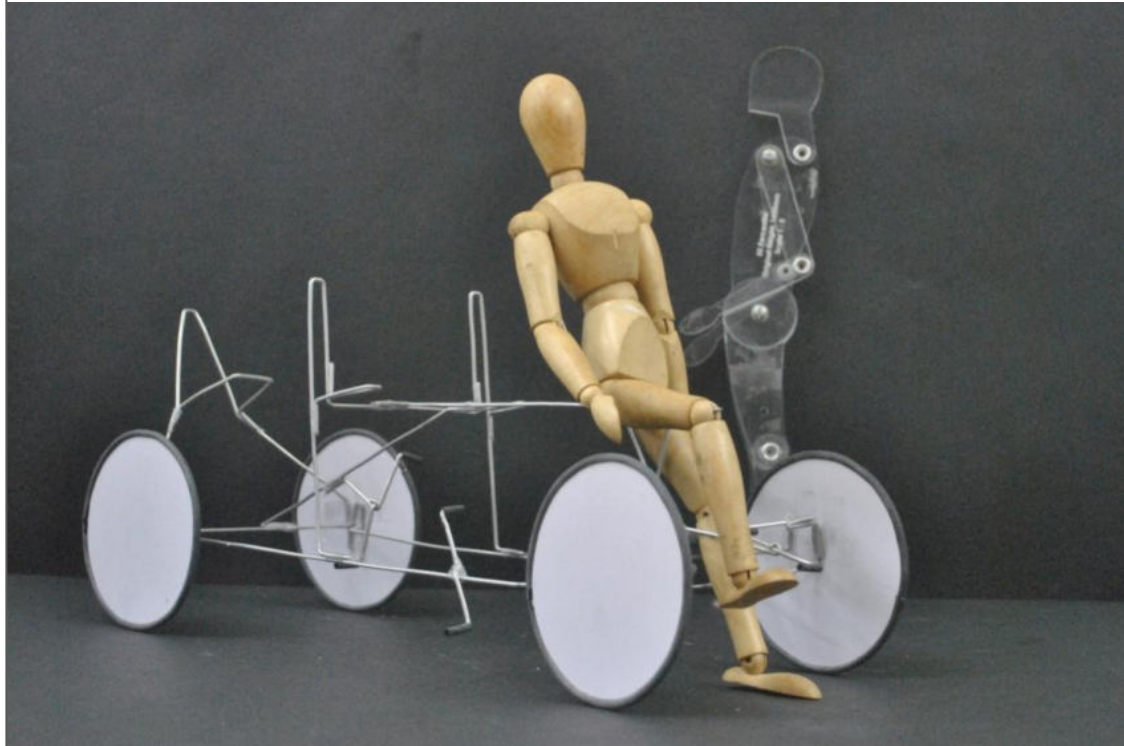
Evaluation

The concepts are self evaluated considering factors such as safety ,practicality,ingress ,egress and also with drive and steer systems.

Concepts	Strength	Weakness
C-1 	1.Two seats cycle more practical anytime. 2.Can be joined and disconnected ant time	1.Connecting links has to be carried. 2.Sync two cycle drive is manual, poor alignment leads to power loss. 3.Larger turning radius.
C-2 	1.Compact Qudracycle. 2.Front wheel turning -not increase width. 3.Low turning radius. 4.Differential can be provided to driving wheels	1.Riding behavior is not familiar. 2.Rider in front is exposed , no frame member for protection. 3.Stability issues with narrow track.
C-3 	1.Transformability-narrow for two seats and wide for four. 2.Wider track make it more stable with weight of four	1.Complex suspension and steering system. 2.Larger turning radius.
C-4 	1.Tyre layout similar to existing Qudracycle. 2.Differential can be provided to driving wheels 3.Ease of ingress and egress. 4.Safety for all four occupants by wheels and frame members	1.Larger turning radius.

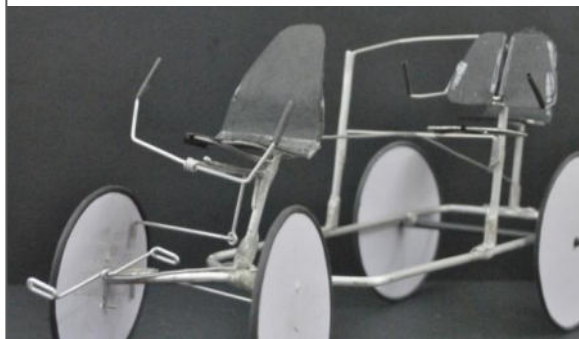
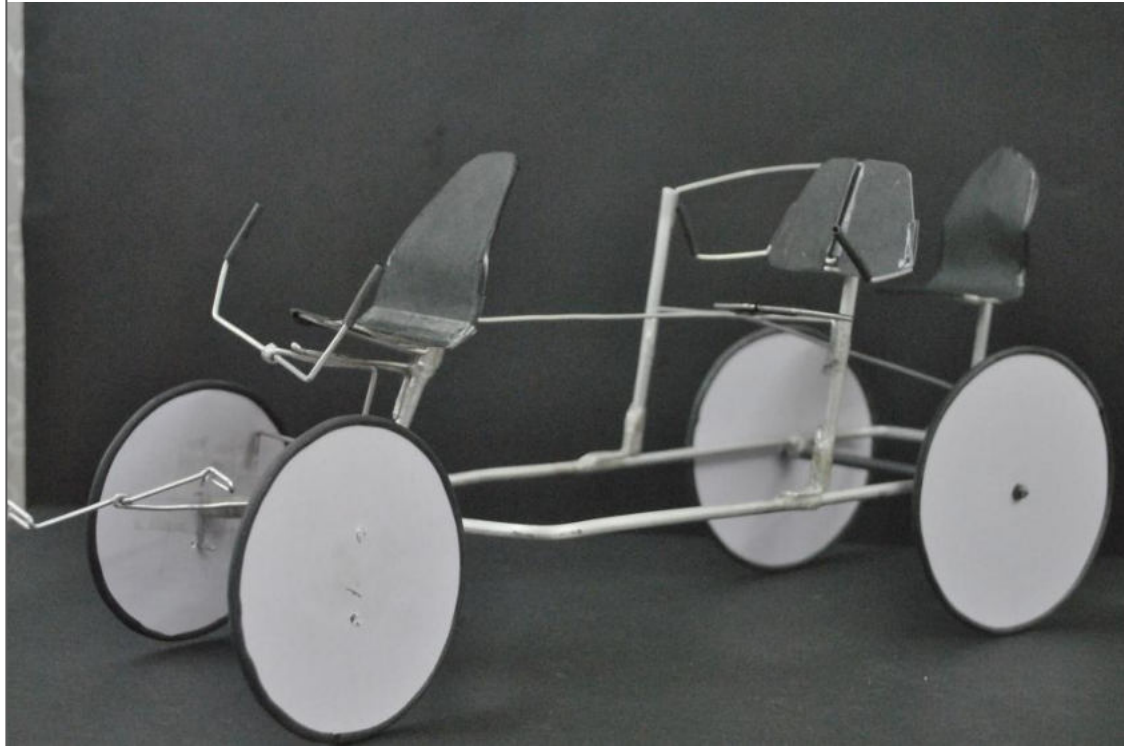
Final concept

Concept-4



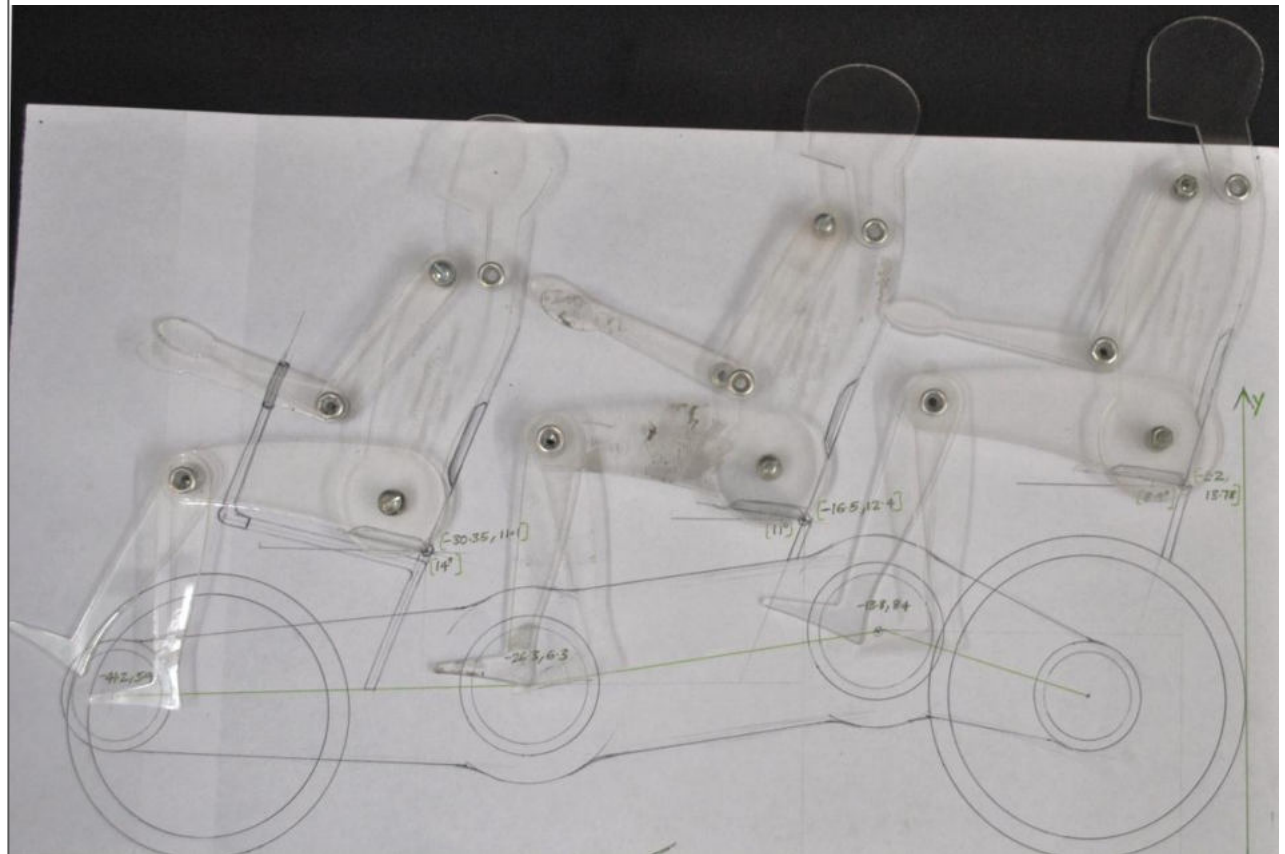
Final concept

Iteration-2



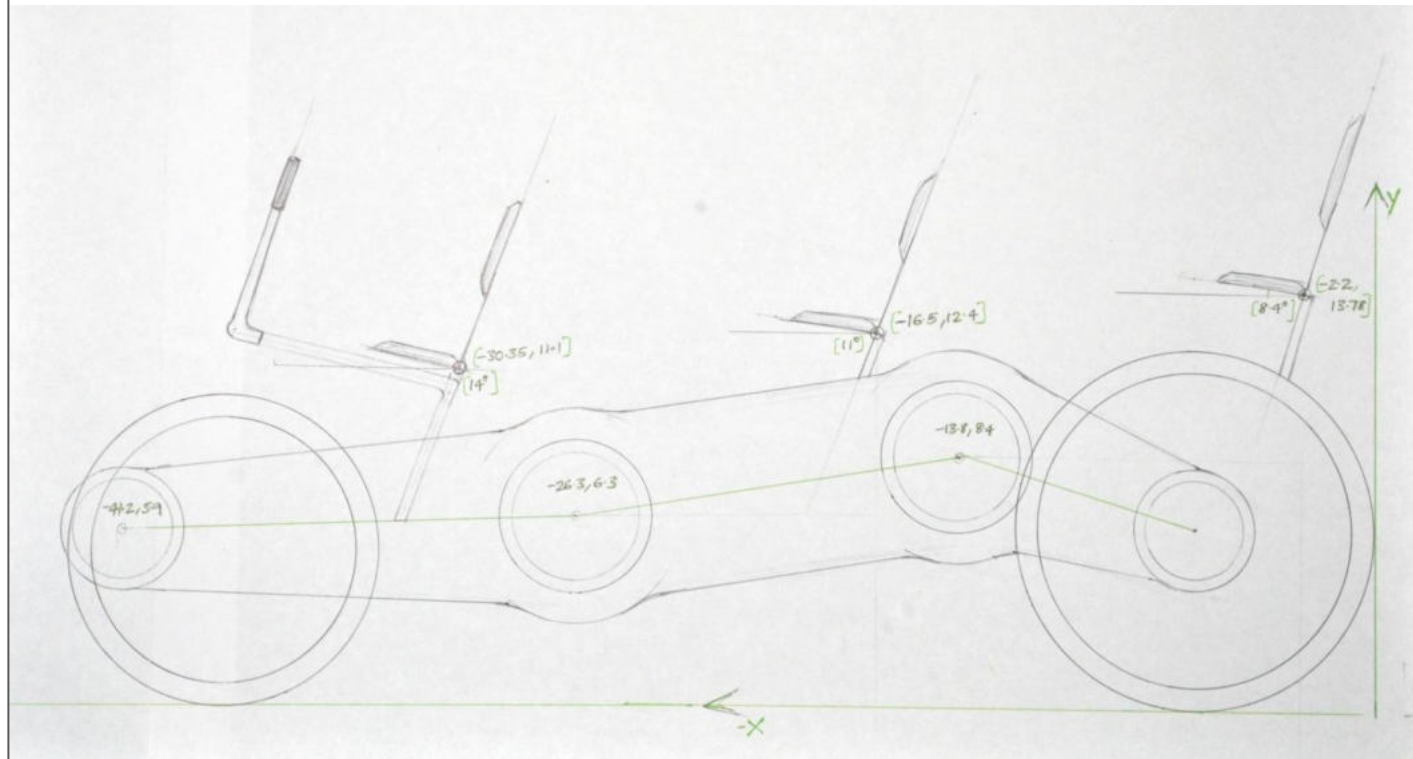
layout

Basic layout



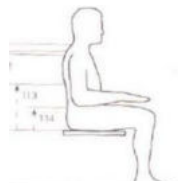
layout

Basic layout



Seat

Seat design

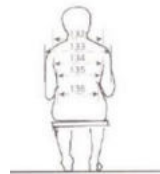


113- Upper lumbar

	5th	50th	95th
Male	254	300	354
Female	226	277	346

114- Lower lumbar lumbar

	5th	50th	95th
Male	72	101	156
Female	66	95	189

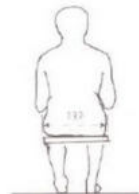


136-waist

	5th	50th	95th
Male	216	259	317
Female	197	231	289

Back rest

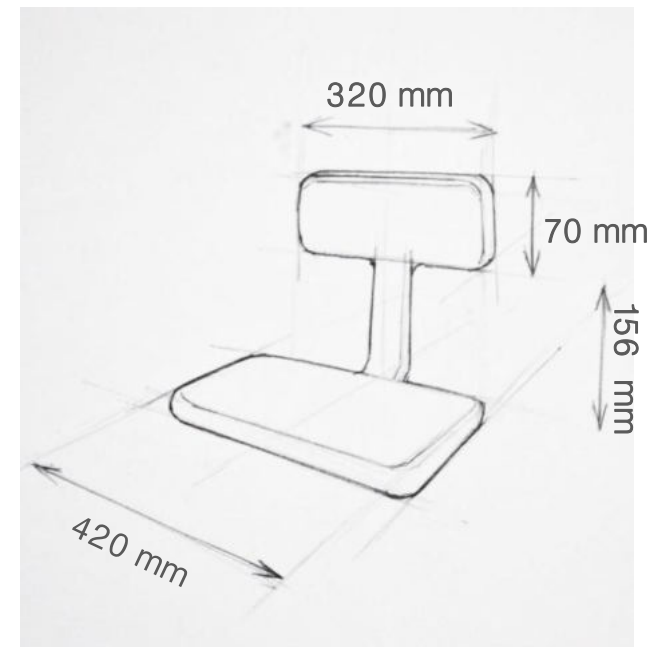
137-Hip breadth



	5th	50th	95th
Male	272	331	405
Female	259	314	429

Width of seat = 420mm

Height of seat rest from base = 156 mm
 Back rest length = 226 - 156 = 70 mm
 Back rest width = 320 mm



Seat

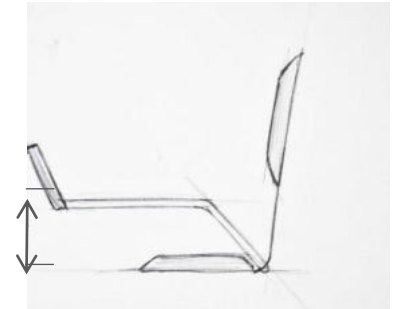
Other Inputs



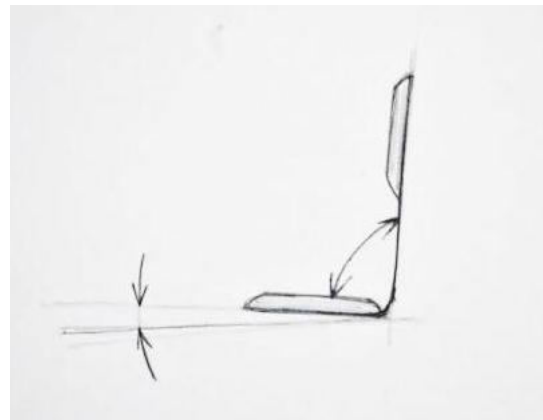
116- Elbow rest

	5th	50th	95th
Male	158	213	270
Female	124	194	265

194 mm



Seat angle

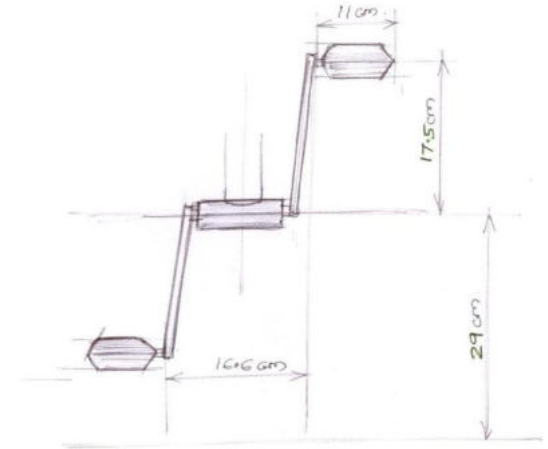


Pedal

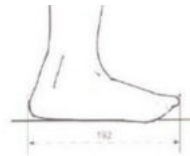
Ergonomic inputs



Hercules Xtreme BMX



192- Foot length



	5th	50th	95th
Male	227	248	274
Female	207	227	249

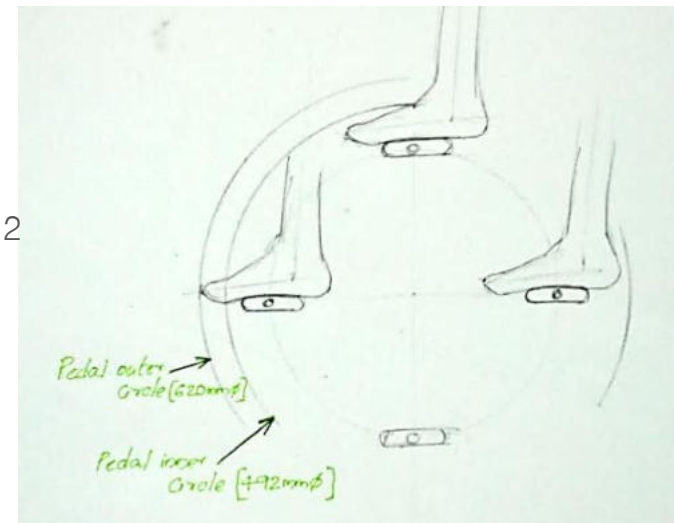
$$\text{Pedal outer circle radius} = 175\text{mm} + 274/2$$

198- Foot depth at middle



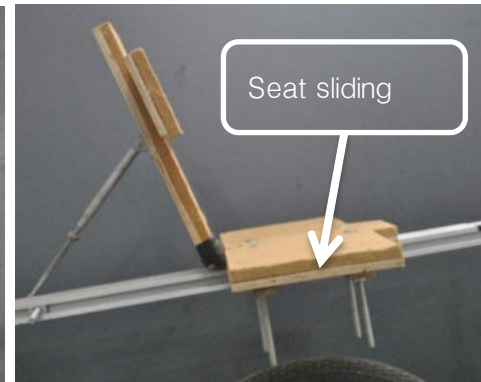
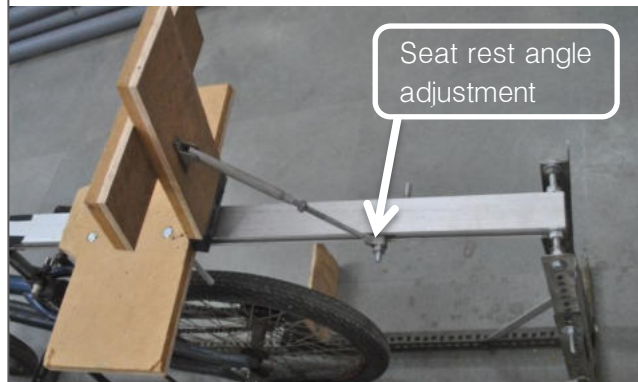
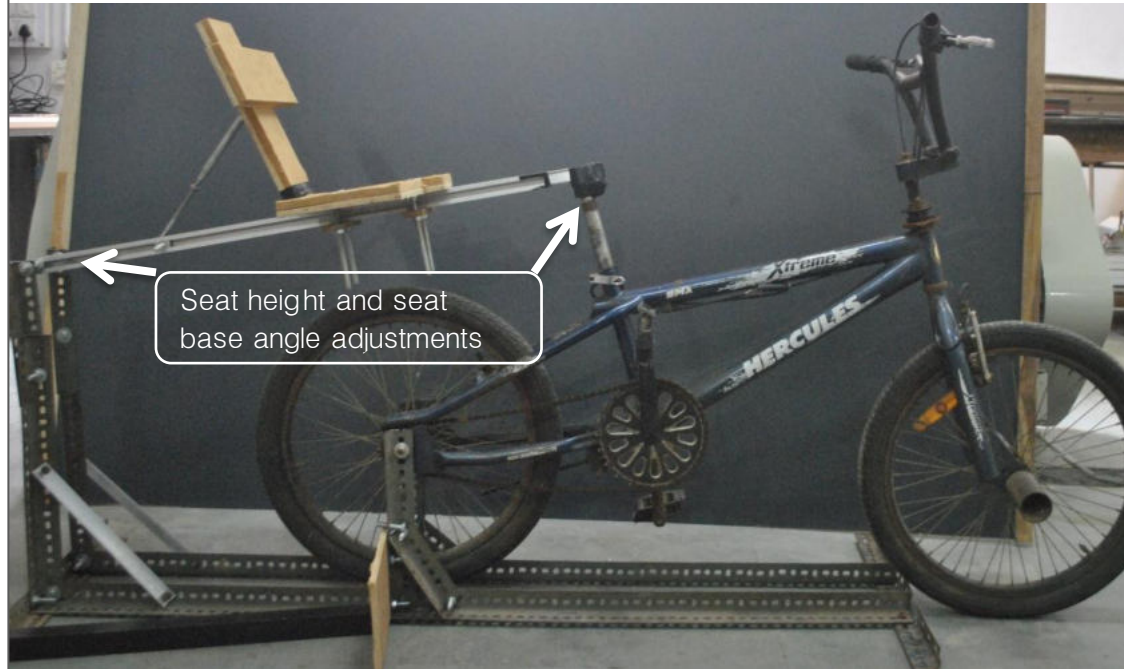
	5th	50th	95th
Male	50	61	71
Female	34	47	61

$$\text{Pedal inner circle radius} = 175\text{mm} + 71\text{mm}$$



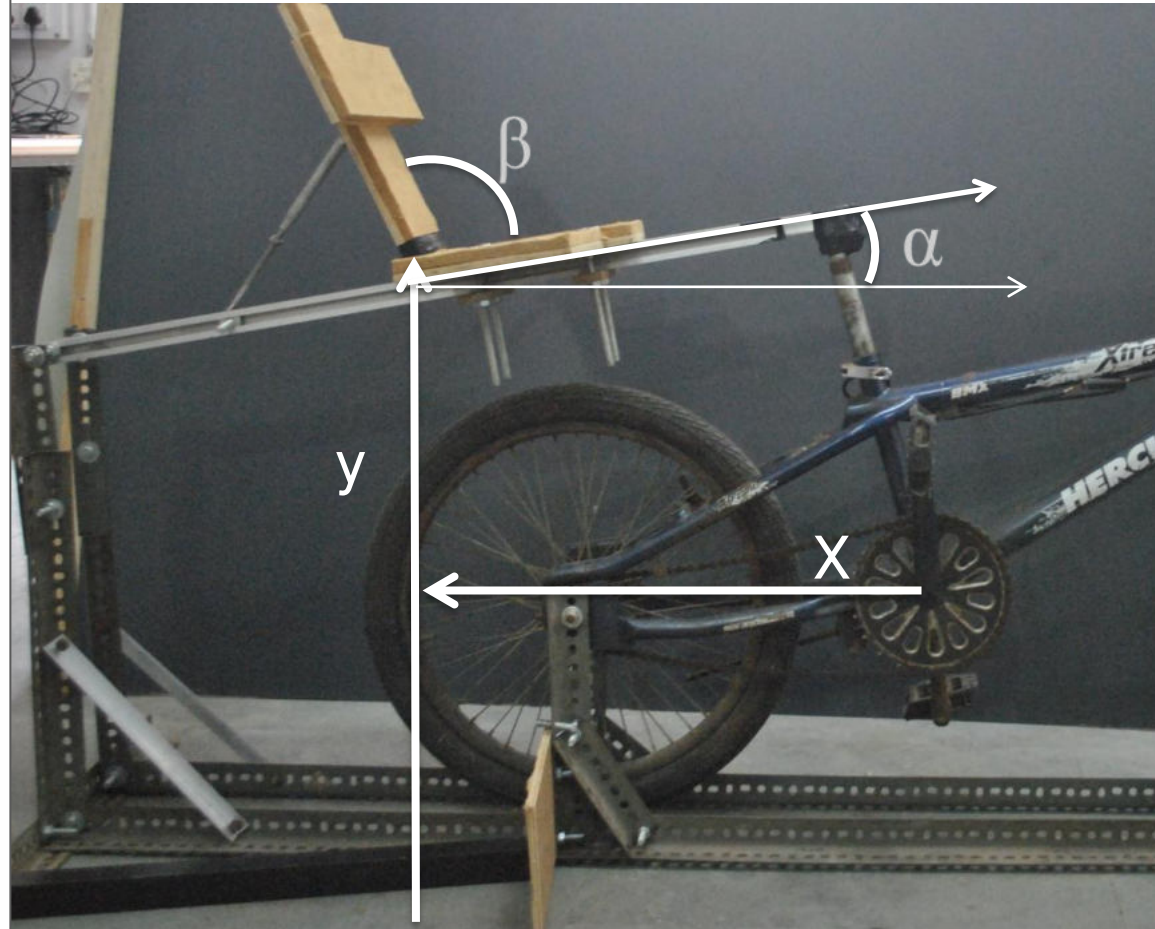
Test Rig

Features



Test Rig

Measurement



Test Rig Measurement



User-1
Height
Alpha
Beta
X
Y

Unni Mohan M
170mm
10°
106°
570mm
700mm

Concluding seat/pedal points

X 570mm
Y 690-790mm
Alpha 10°
Beta 106°



User-2
Height
Alpha
Beta
X
Y

Amar
175mm(95th, 175mm)
10°
106°
610mm
760mm



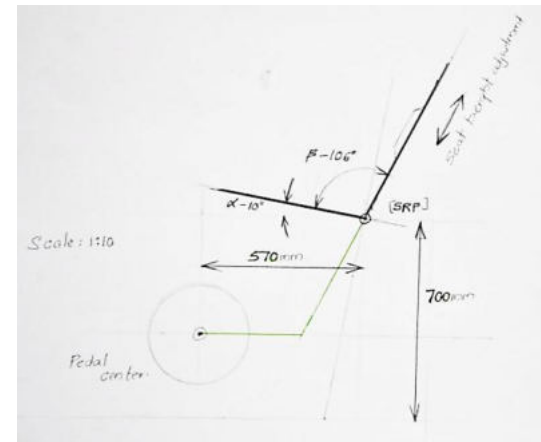
User-3
Height
Alpha
Beta
X
Y

Kiran
169mm
10°
106°
590mm
650mm



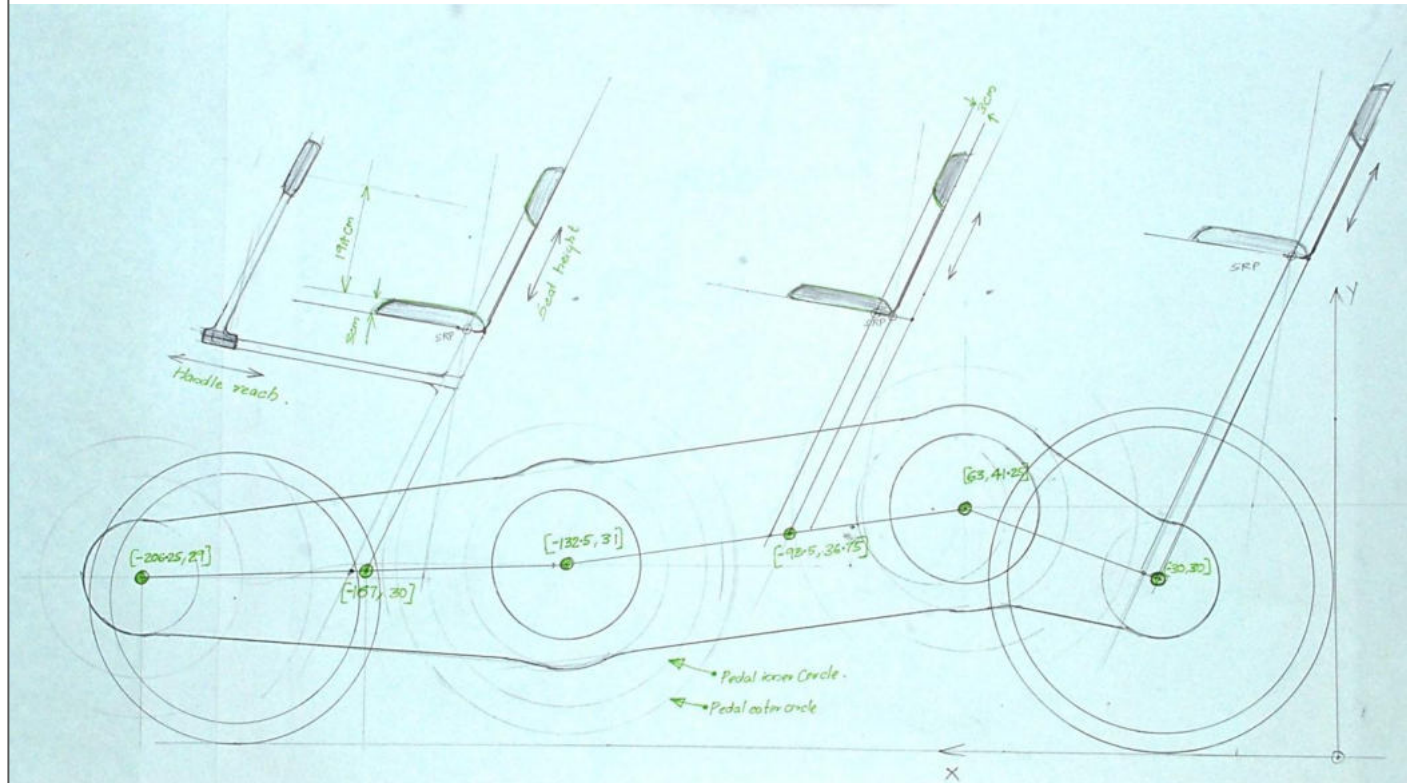
User-4
Height
Alpha
Beta
X
Y

Gayathri
158mm (5th -153mm)
10°
106°
530mm
690mm



layout

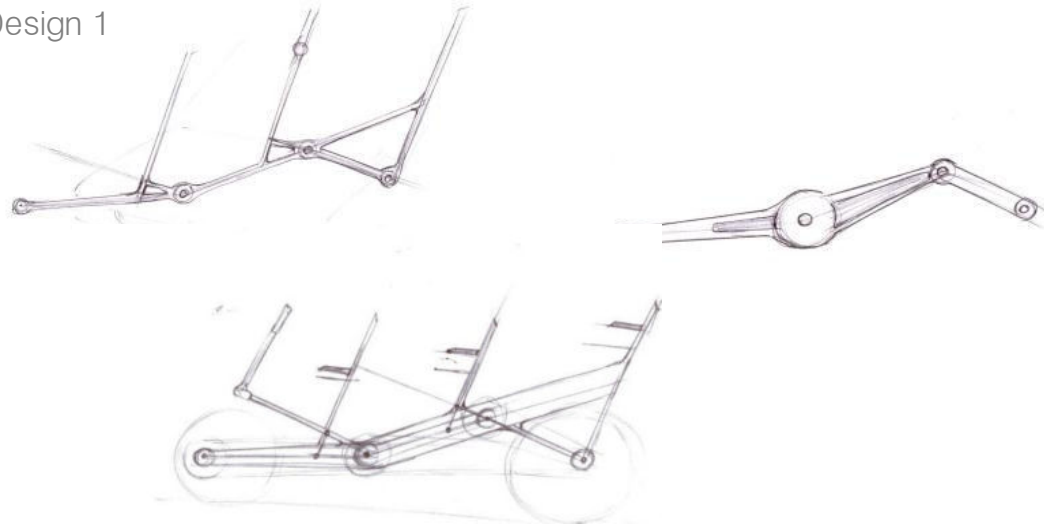
Modified



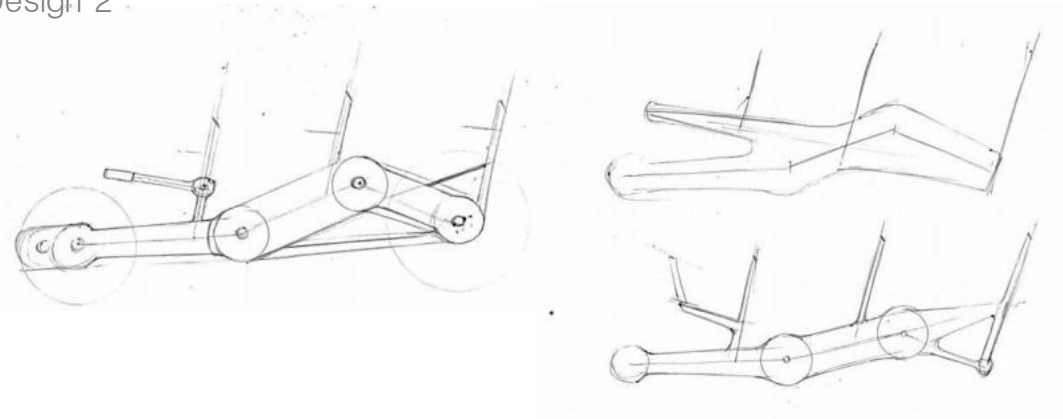
Ideation

Inputs for design

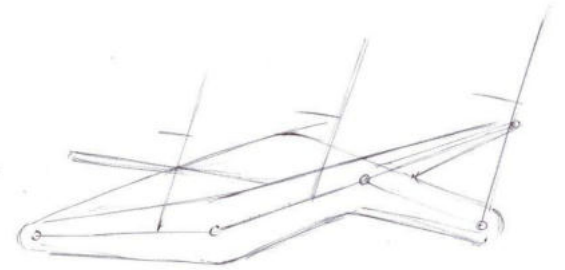
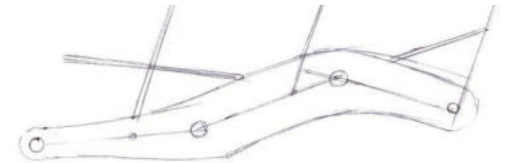
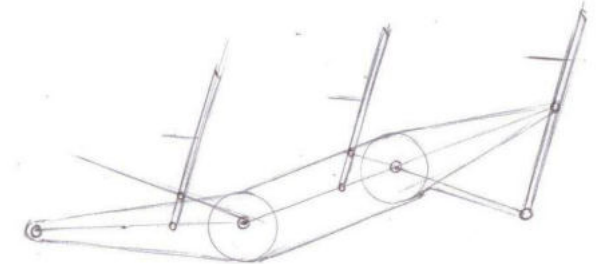
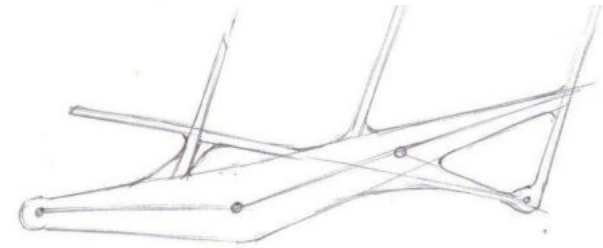
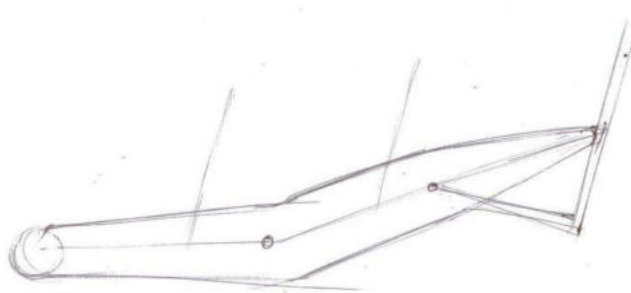
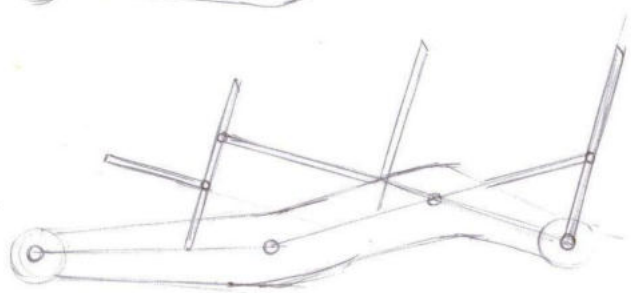
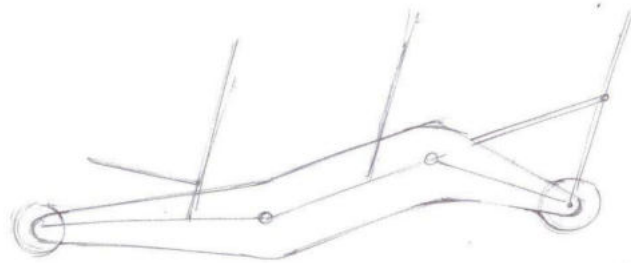
Design 1



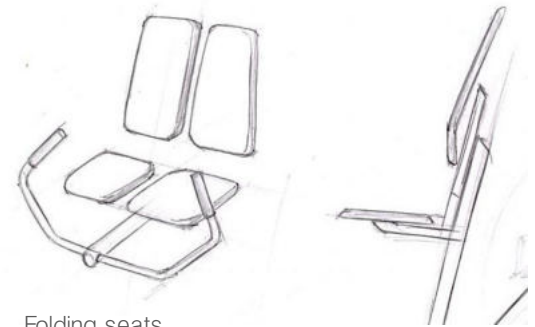
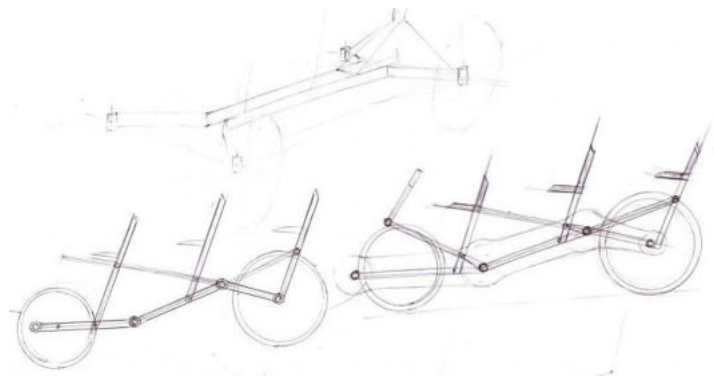
Design 2



Sketches

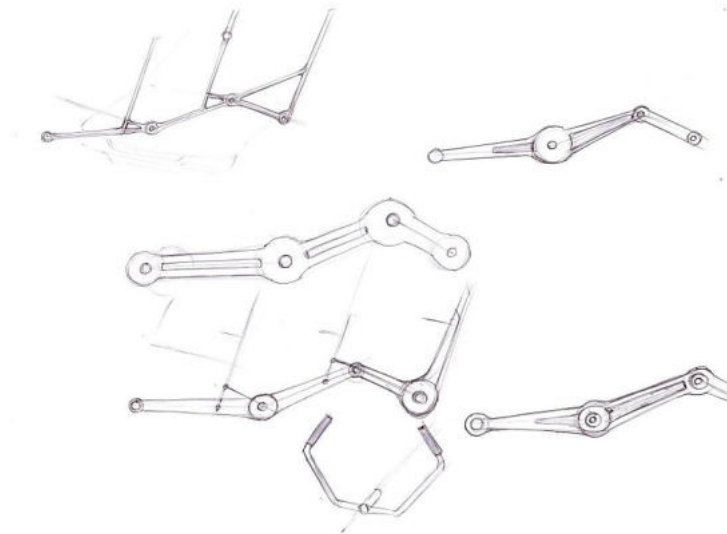


Sketches



Folding seats

Seat sliding for height adjustability

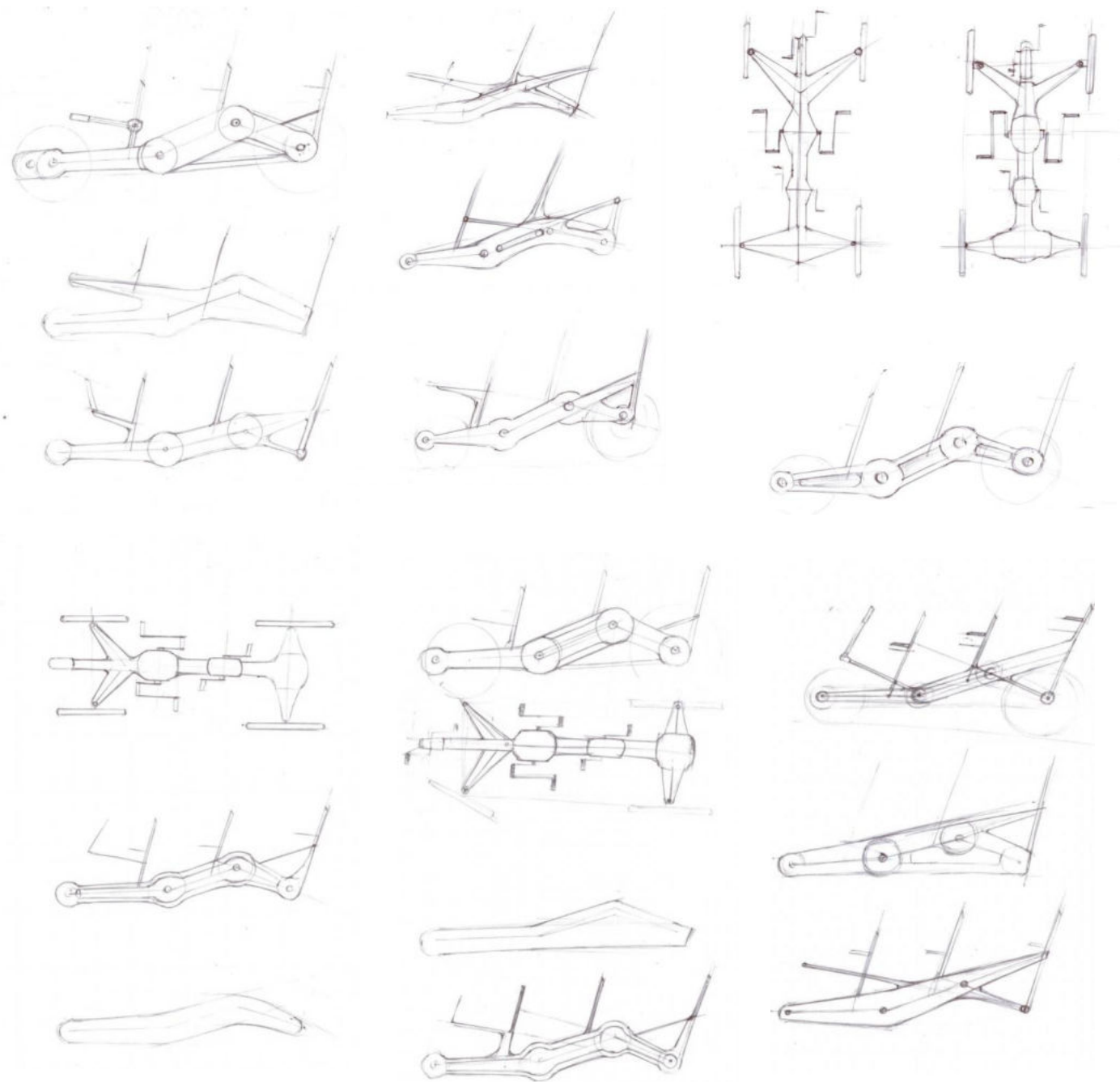


Frame elements used for structural strength with multiple connections.

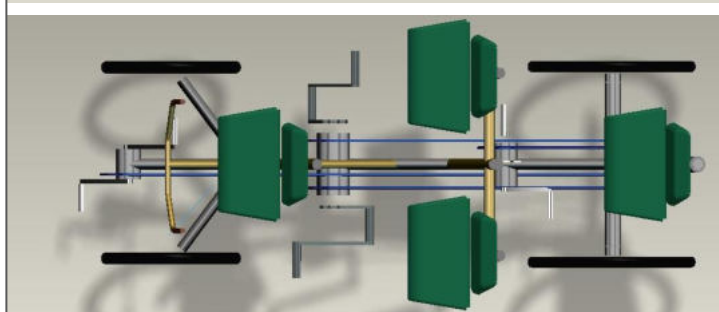
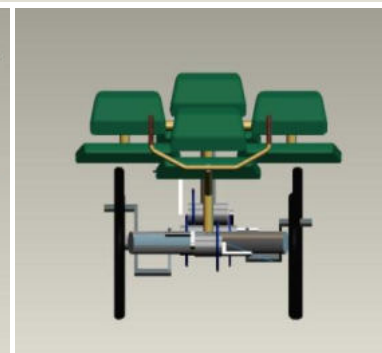
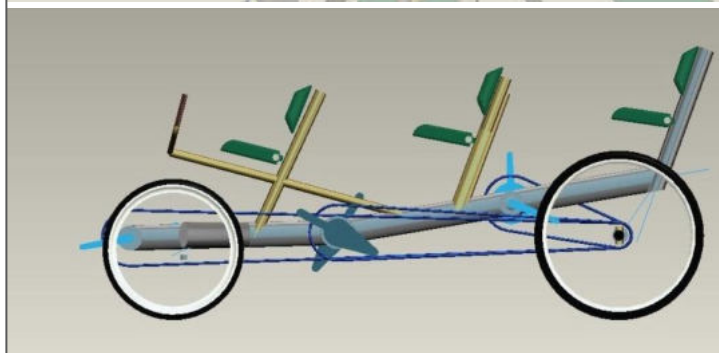
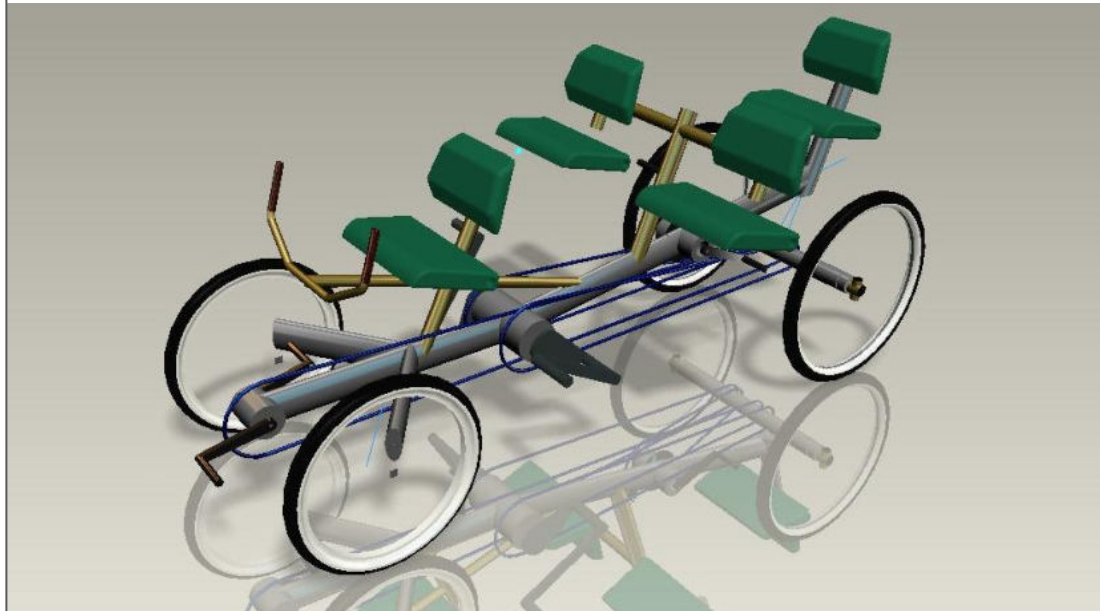


More ideations on adjustability

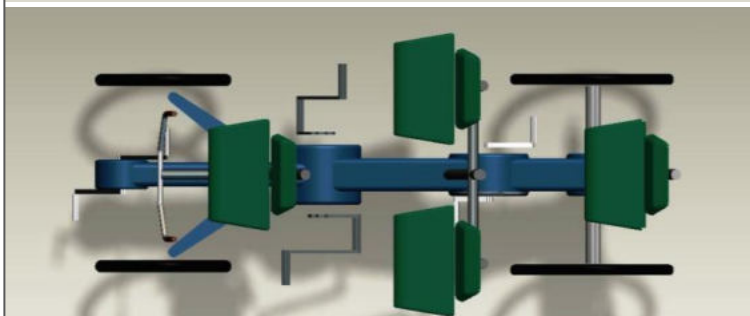
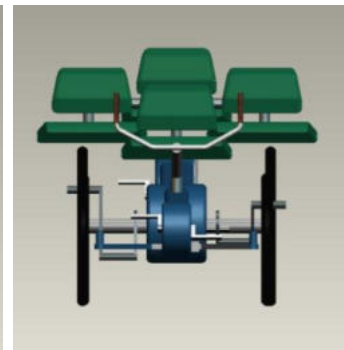
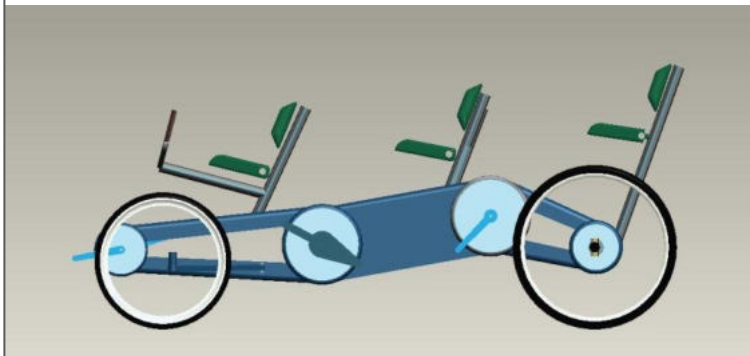
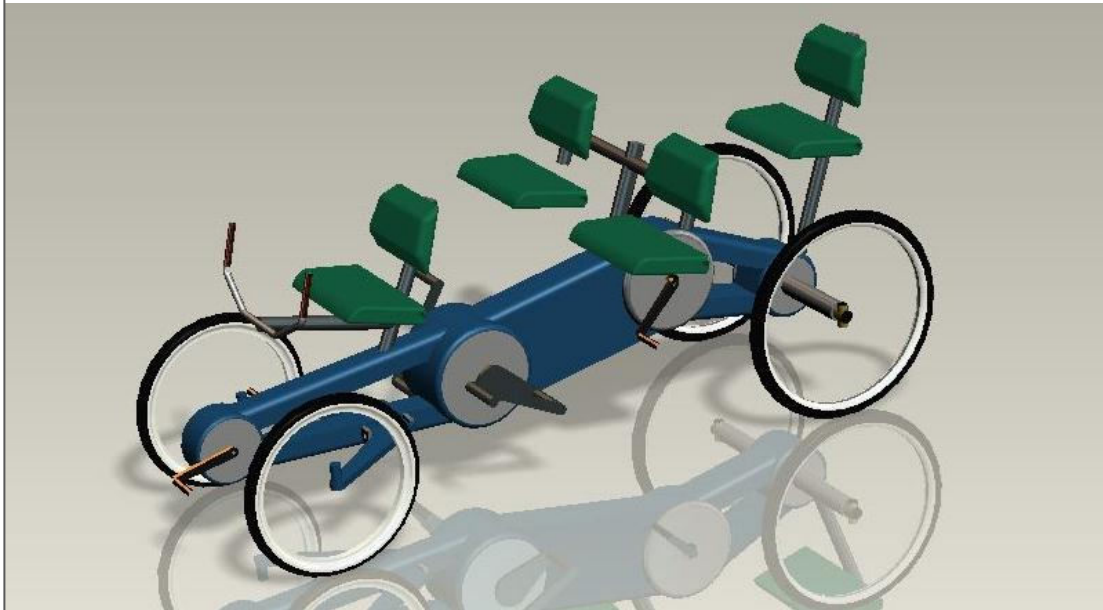
Sketches



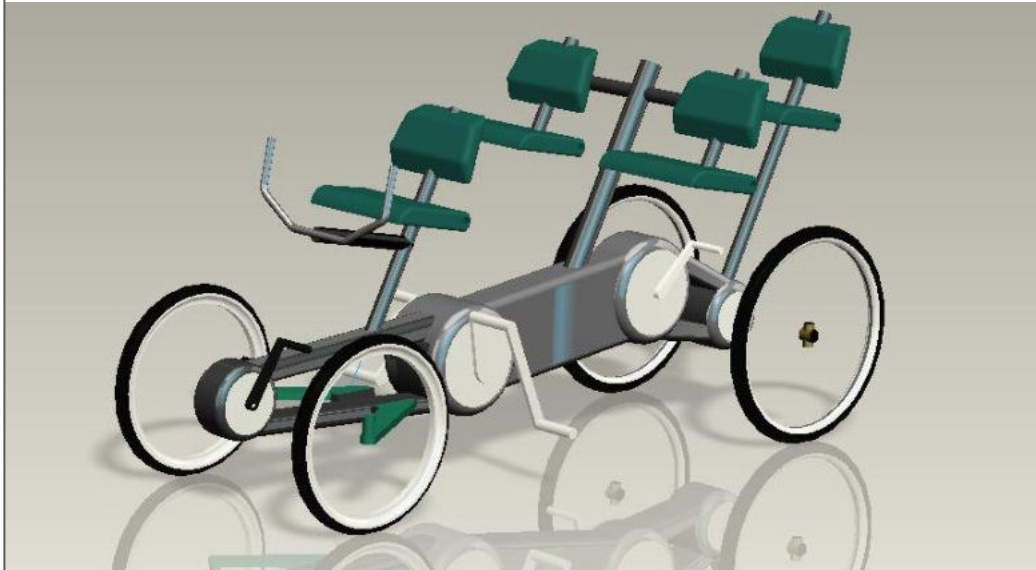
Design-1



Design-2



CAD layout



Specifications

Length with front pedals vertically placed	2200mm
Length with foot at extreme position	2350mm
Total width including seats	1040mm
Total width (with 95 th percentile)	1240mm
Width with middle seats folded	750mm
Track	750mm
Wheel base	1600mm

Keywords for **Aesthetics**

Light weight

Inviting

Agile

safe

sleek



[IR-66]

agile



[IR-67]



[IR-65]



[IR-64]

[IR-63]



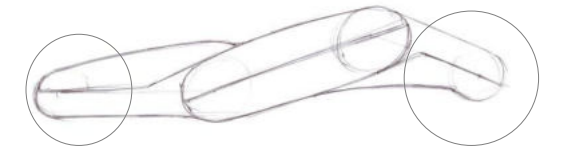
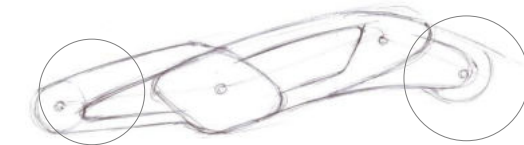
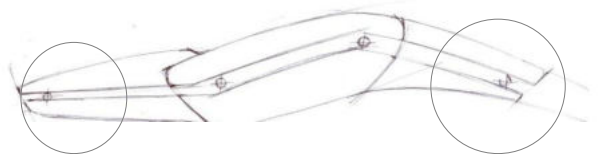
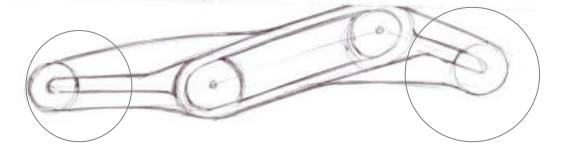
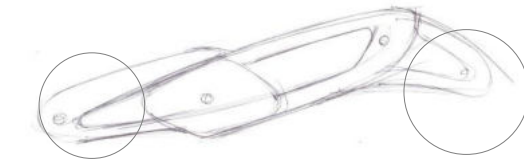
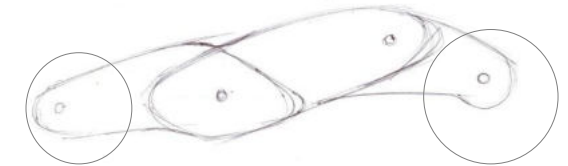
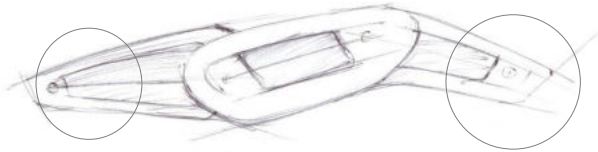
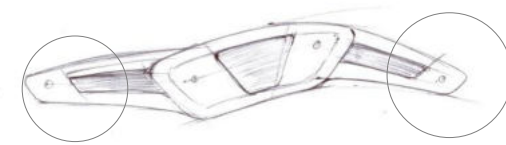
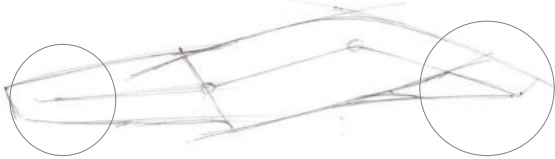
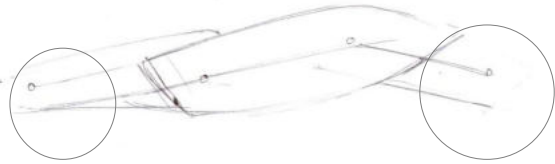
agility in dance

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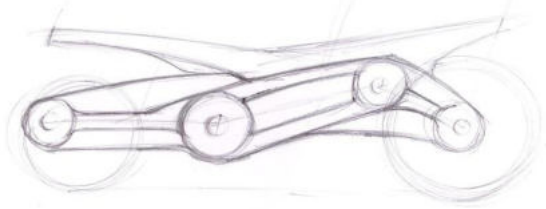
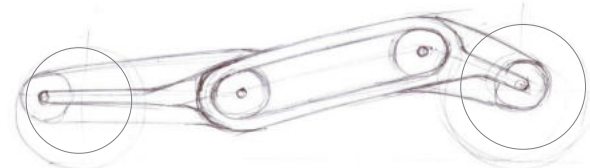
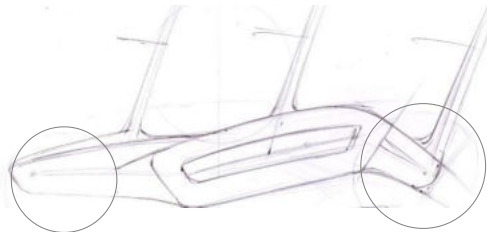
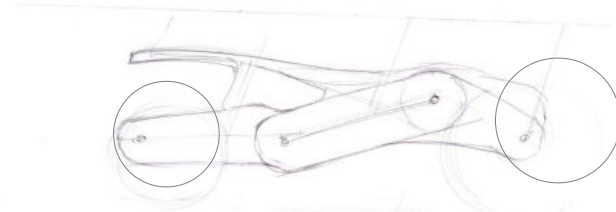
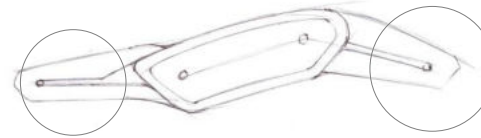
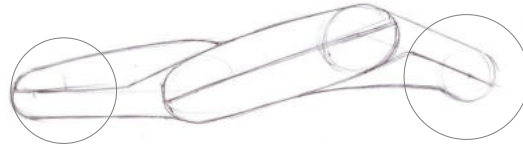
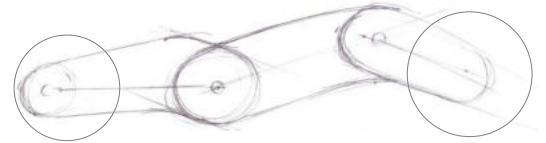
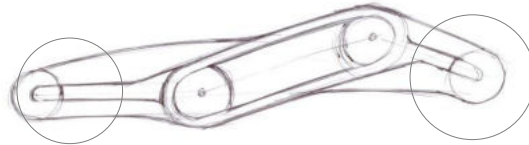
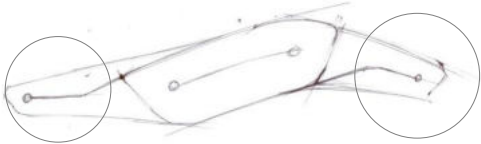
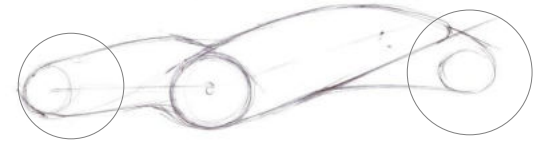
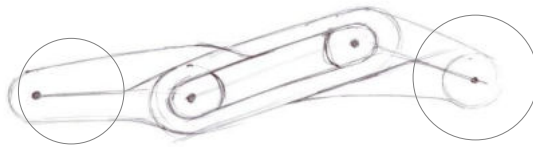
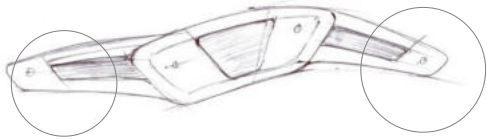
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[IR-69]

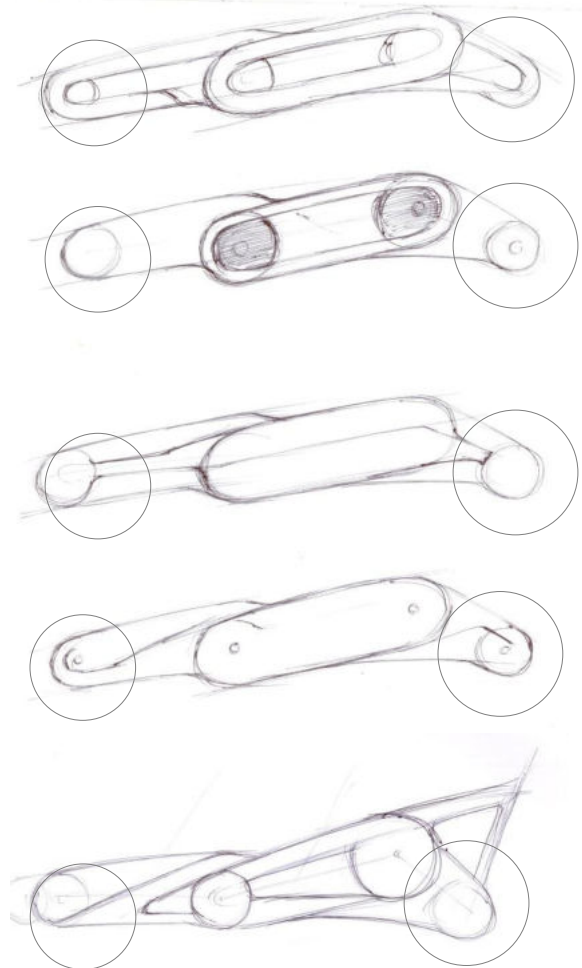
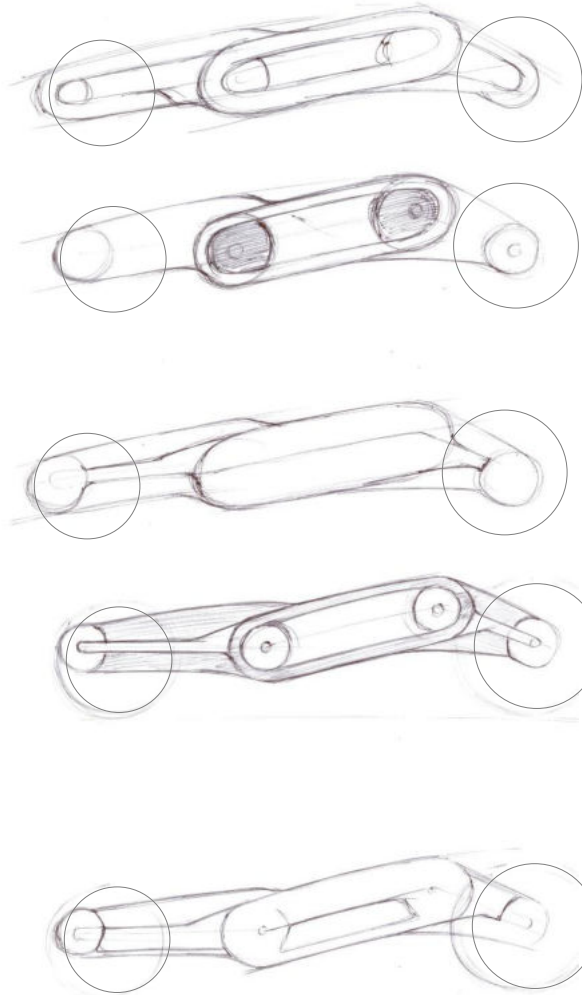
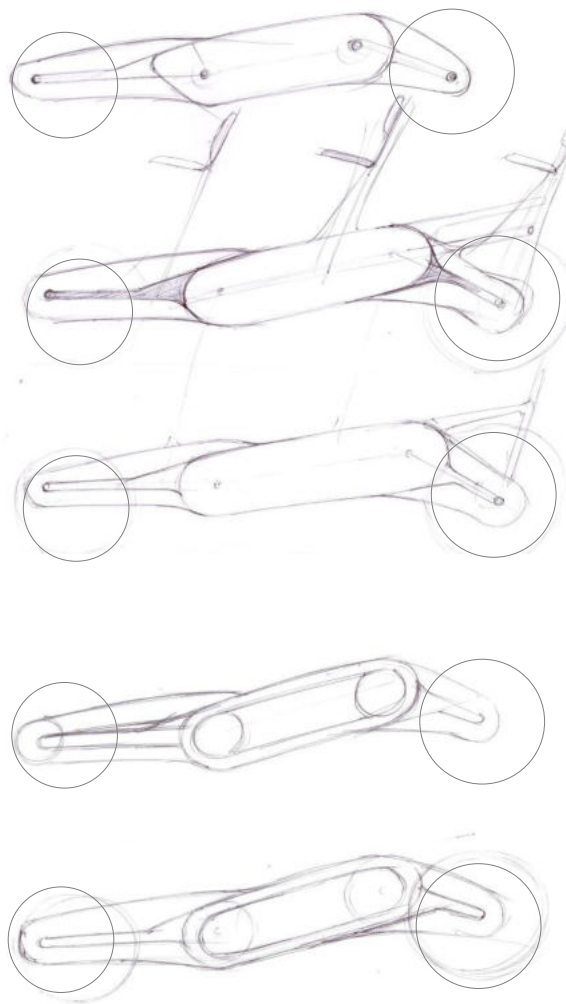
Sketches



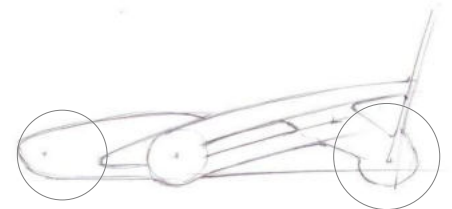
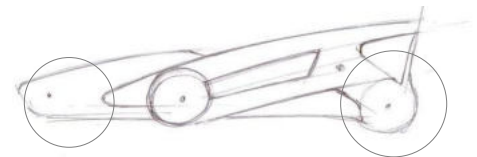
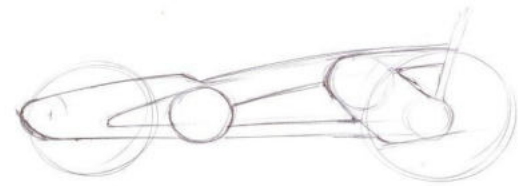
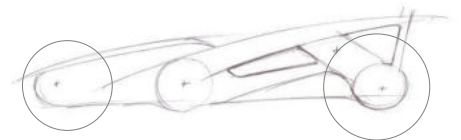
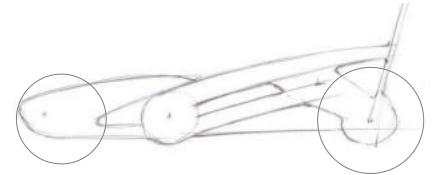
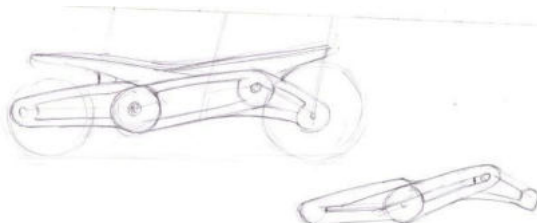
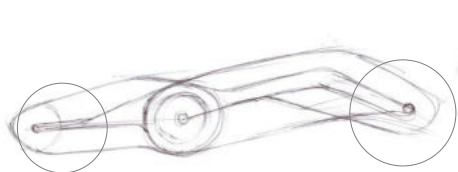
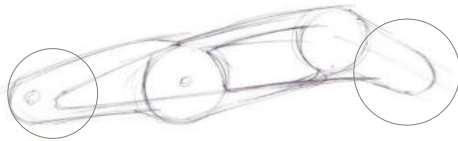
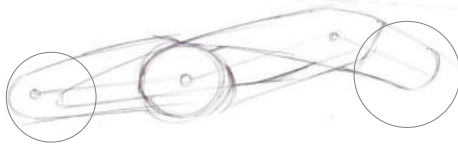
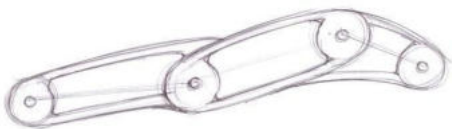
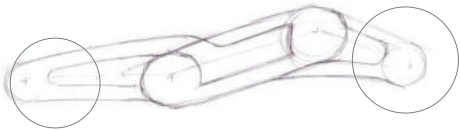
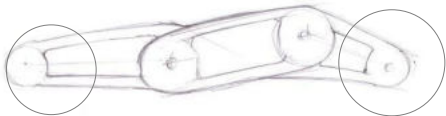
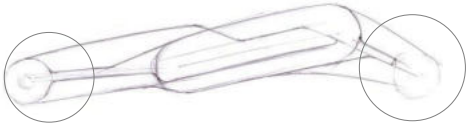
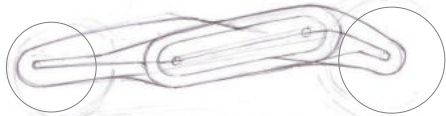
Sketches



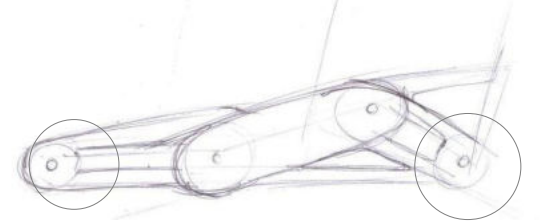
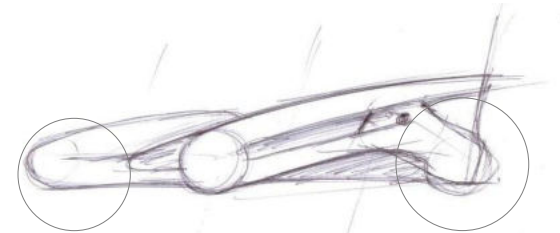
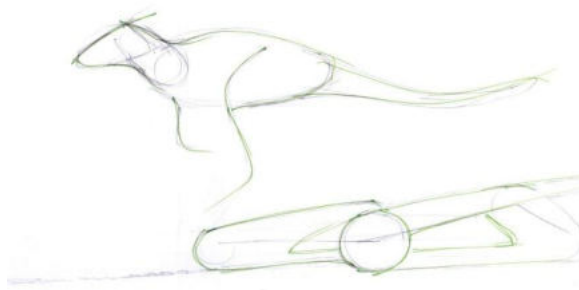
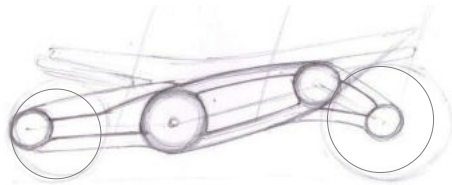
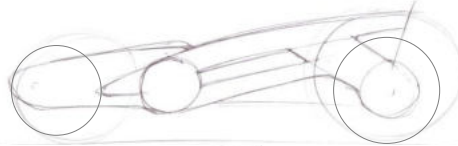
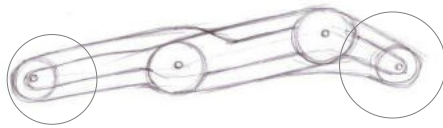
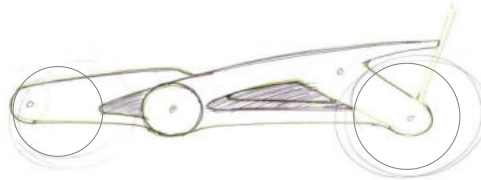
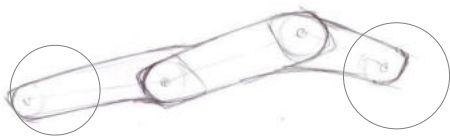
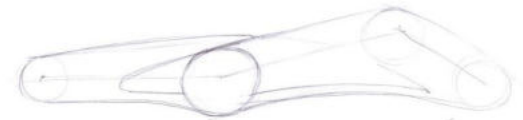
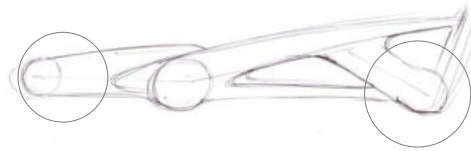
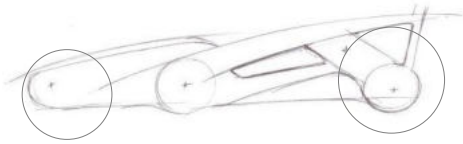
Sketches



Sketches

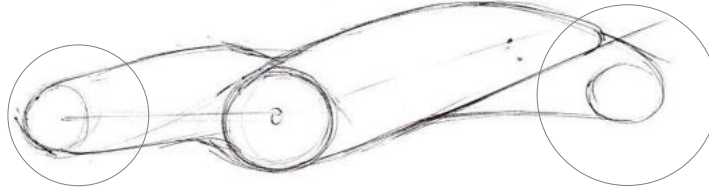


Sketches

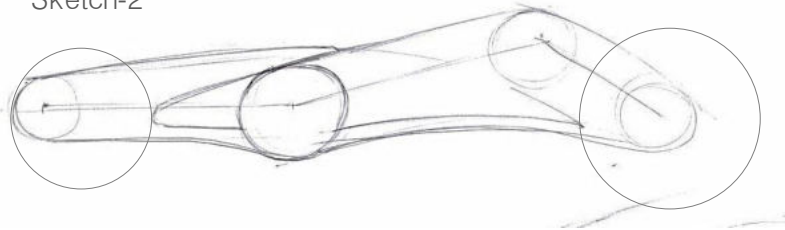


Selected sketches

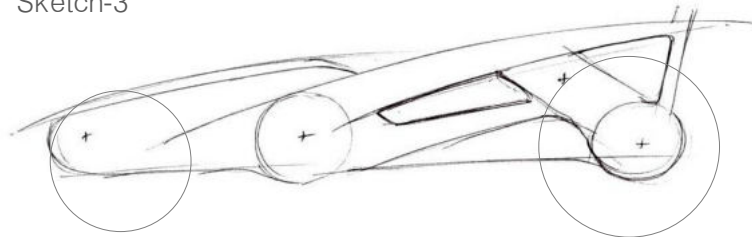
Sketch-1



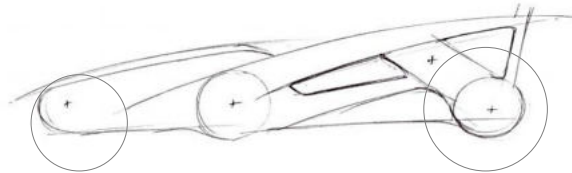
Sketch-2



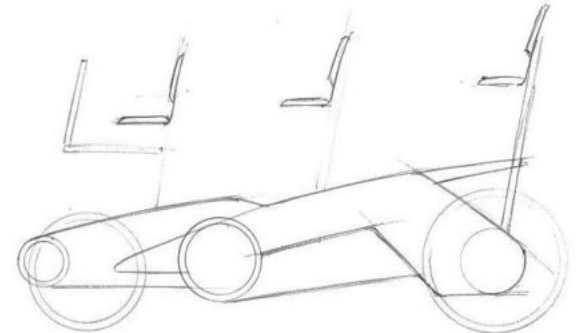
Sketch-3



Development

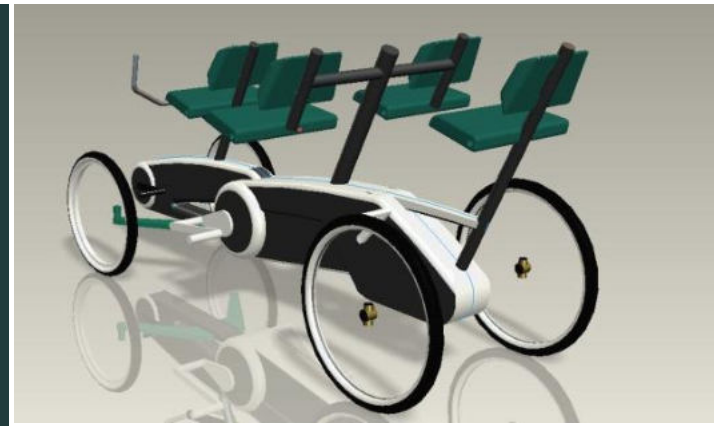
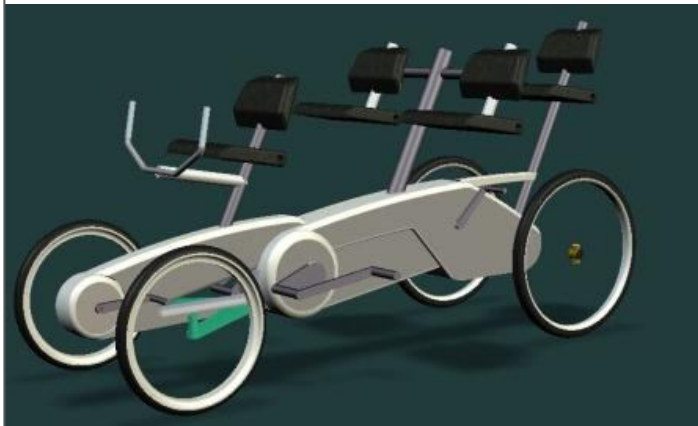


Sketch-3 is selected for development
Lines seems to be fast an confused

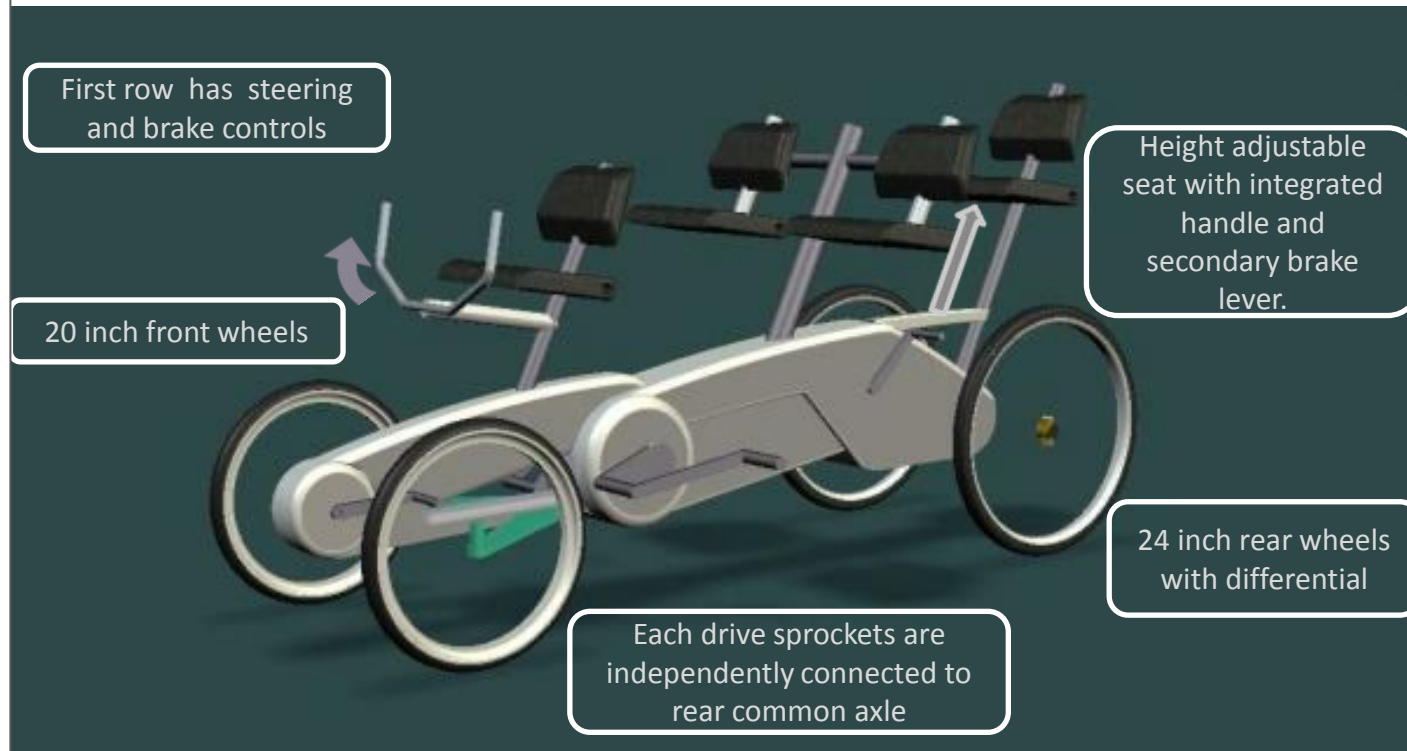


The sketch was modified to reduce fast lines and to bring agility.
To make it more agile ,line to bring hopping character is tried out.

After finalizing side profile, a 3-D model is made in Pro-E with simple fillets to get final volumes and proportions.



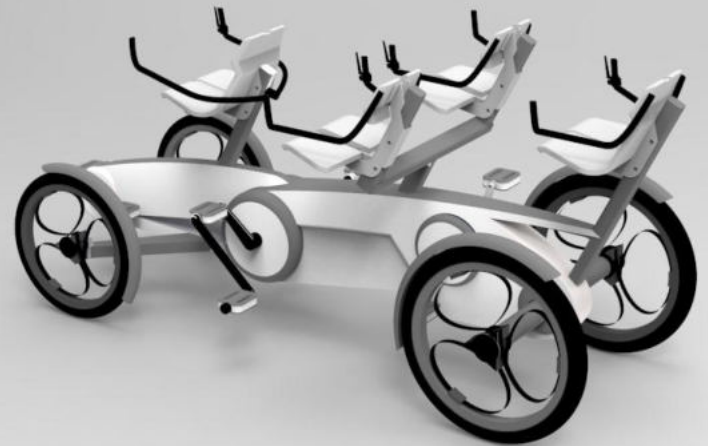
Features



Final design

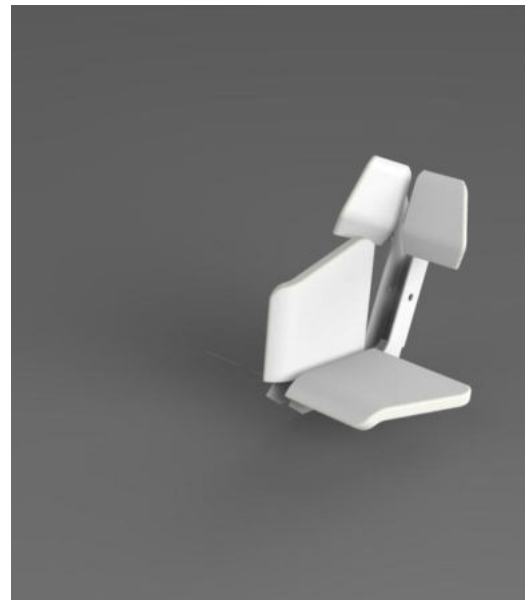
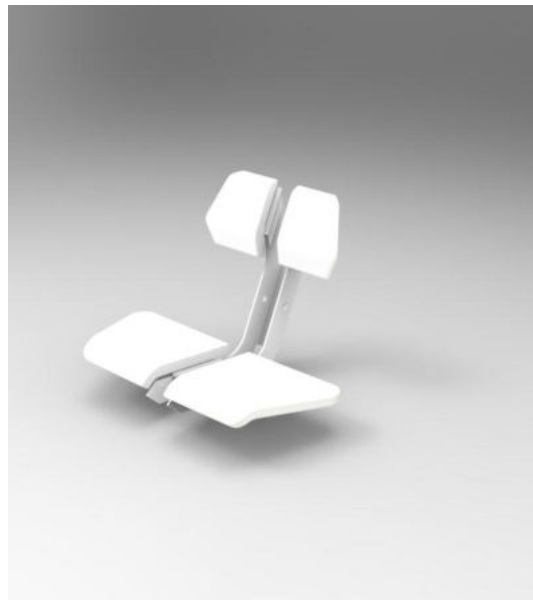
Cad models are generated to demonstrate the final styling and layout of the design. The images shown here are various renders of the cad model generated to explain the same.

Wheels are from **loopwheels**.
Loopwheels are bicycle wheels with integral suspension



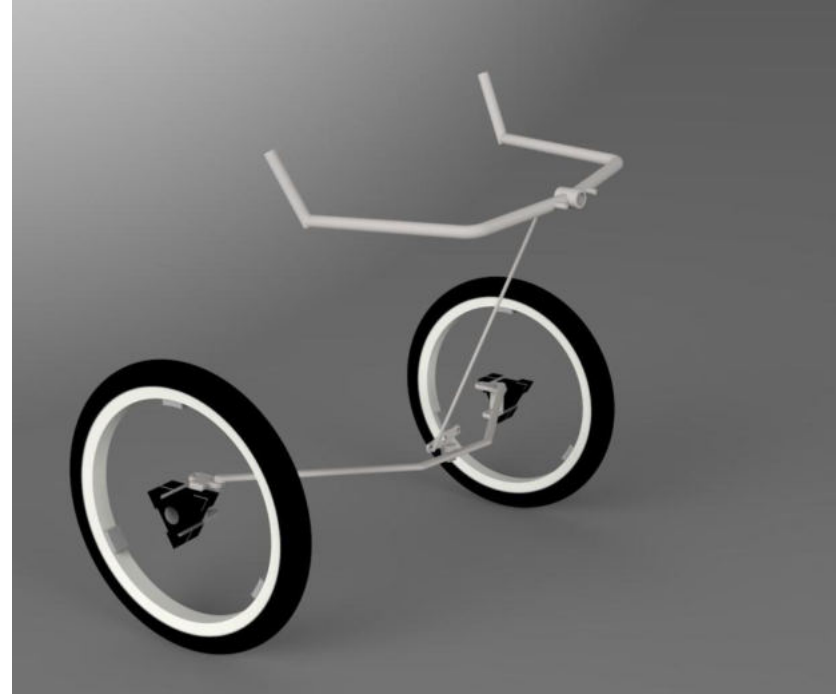
Details

Foldable seat and sheet metal support.



Details

Images shows steering assembly.



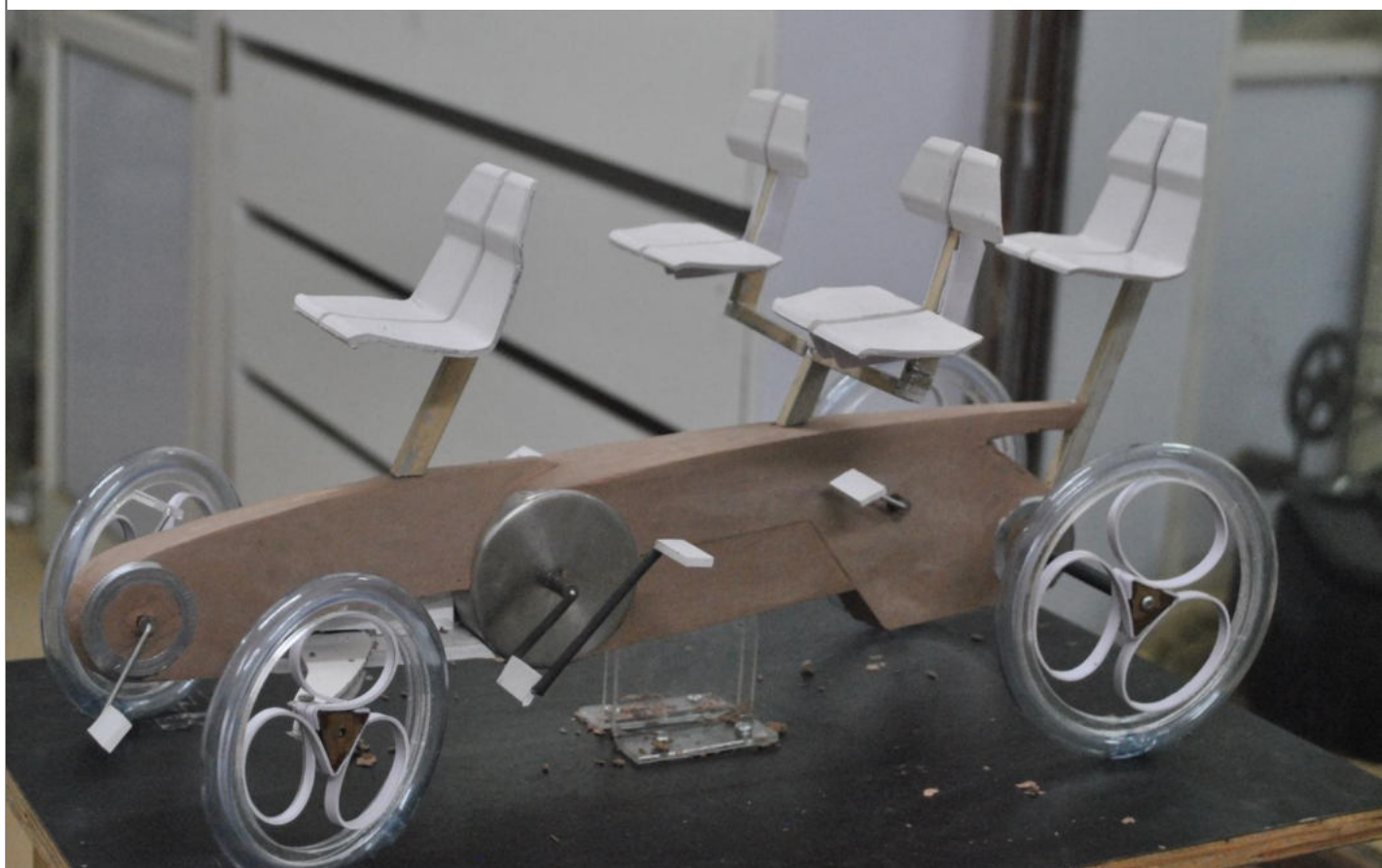
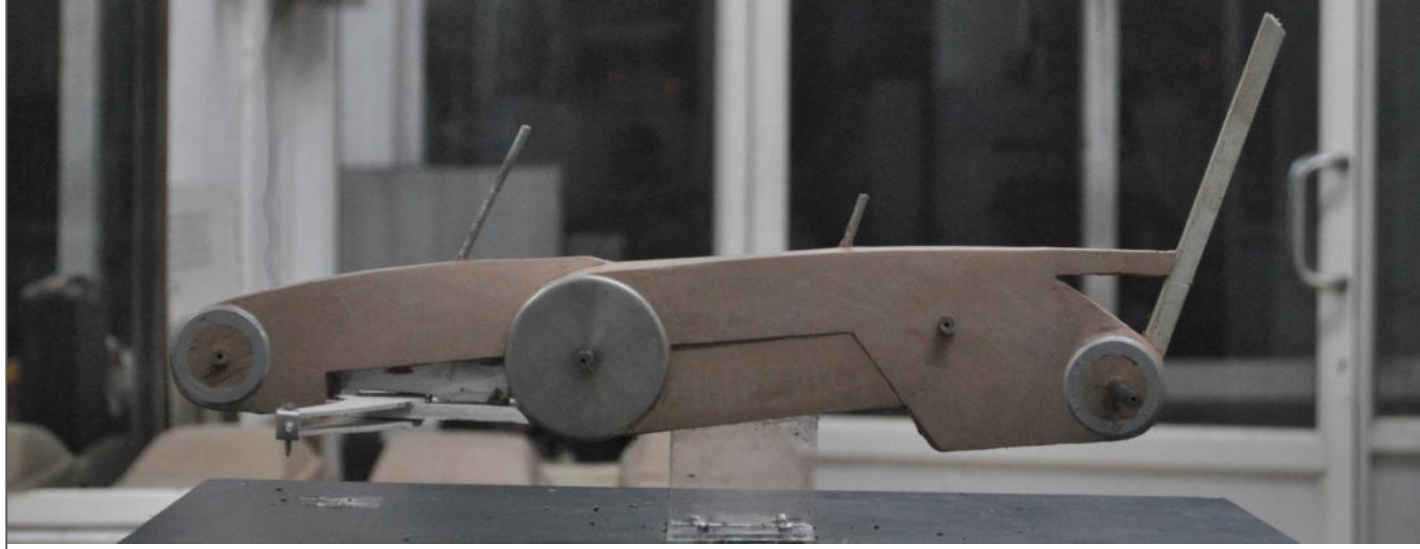
Final render



Wheels are from loopwheels

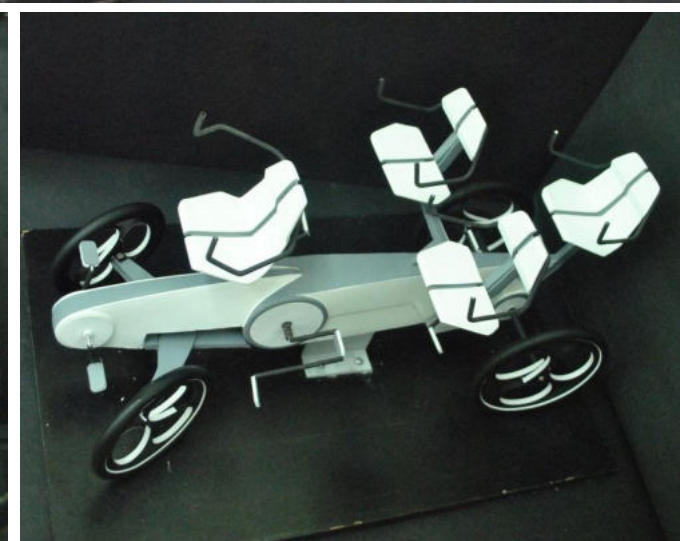
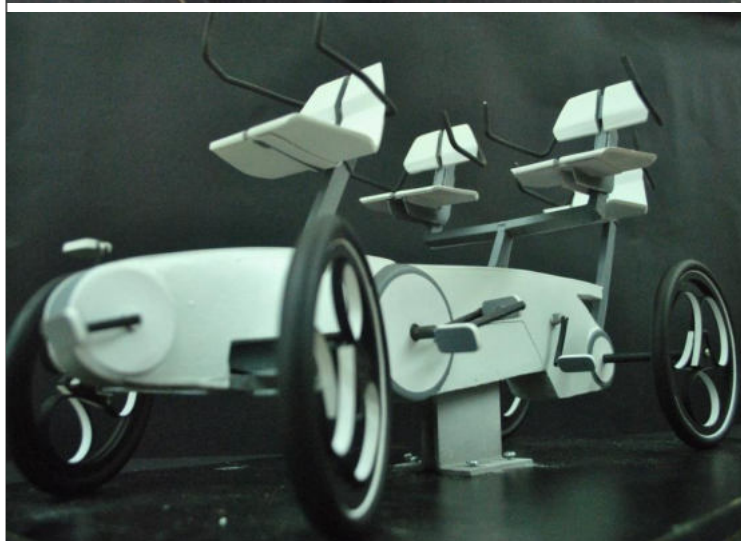
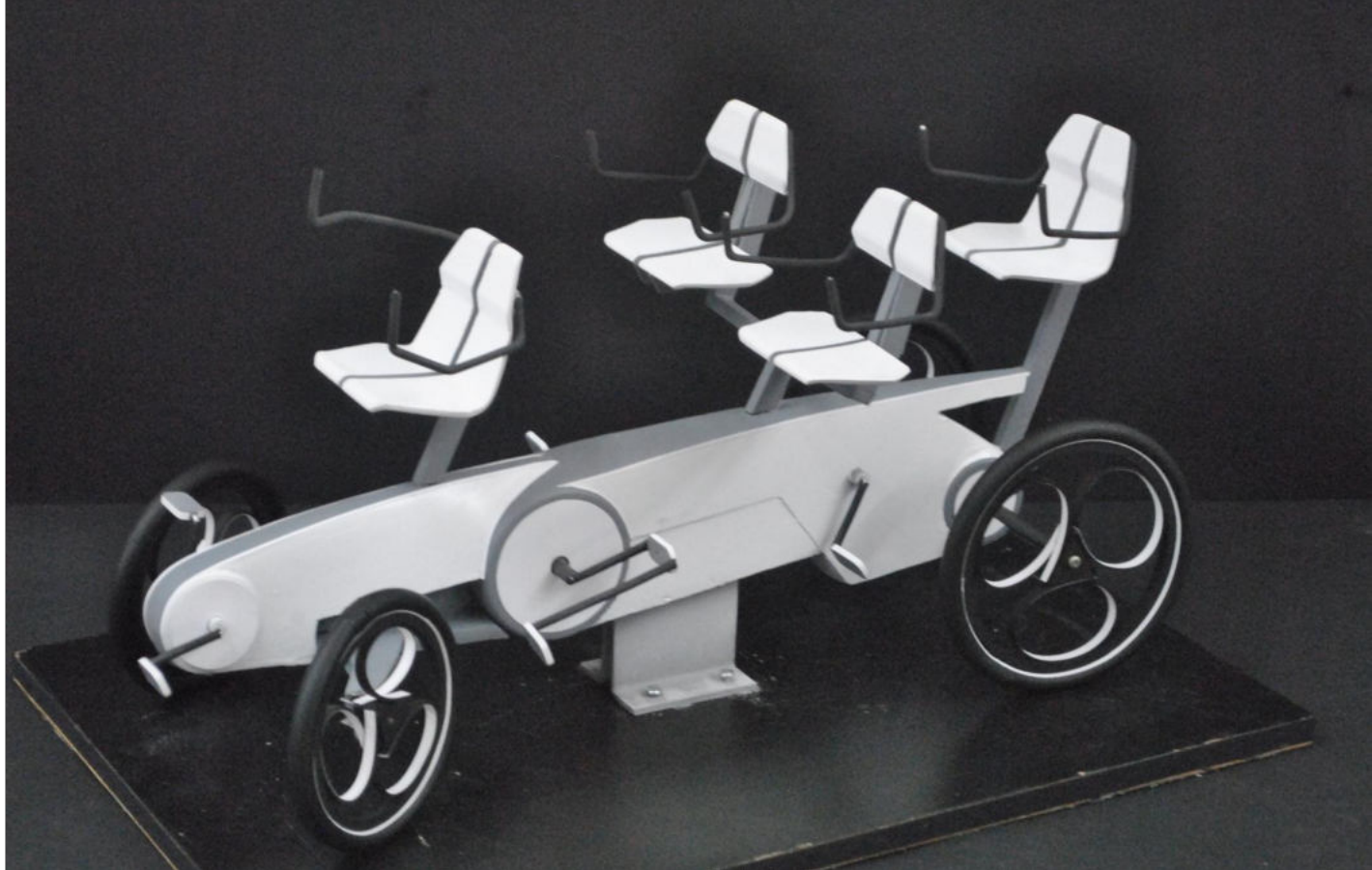
Scaled model

development



Wheels are from loopwheels

Scaled model



Wheels are from loopwheels

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Thank you