Project-3

Designing electric bicycle for college student

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Declaration |

I hereby declare that this project is done mainly with my ideas in my own words. And all the collected data that helped me in processing further has been sited accordingly. I assure that there is no misinterpretation, misuse or any kind of falsified data or resource in the project and the document. I understand that in case of violation of above could cause the disciplinary actions from the institution or the sources from which proper permission has not been taken or improperly cited.

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Approval sheet |

This Mobility & Vehicle Design project report entitled “Designing an electric bicycle for college student”, by Roshan Kumar Sahu is approved in partial fulfilment of the requirement for Master of Design degree in Mobility and Vehicle Design.

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Abstract |

Bicycles are a wonderful means of transportation that helps preserve the environment, it reduces air contamination, ecological footprints, carbon emissions, is healthy and very inexpensive. The electrical bicycle or e-bike is a traditional bicycle equipped with an electric motor to help with pedalling. They are more economical than fuel-powered cars and motorcycles, and cheaper than buying an electrical vehicle for the city. Interestingly, in the age of big-buck motor cars, electric bicycle appears to be increasingly adopted as a refreshing alternative because they have several advantages. College students uses different mode of transportation to travel within campus. The available options for transport for students are personal bicycle, bus, shared cycle, auto-rickshaw, etc. They have to travel frequently between places within there large college campus. Most convenient mode of transportation for student in many institutions was found to be personal bicycle. The vision for the project is to provide an efficient solution for mobility of college students from one place to another. The main intent is to research on the problems with existing mode of transportation and solving them to provide an efficient solution. The new design will be an options for student against expensive bicycle.

1. Introduction

1.1 Introduction |

An electric bicycle also known as an e-bike is a bicycle with an integrated electric motor which can be used for propulsion. Many kinds of e-bikes are available worldwide, from e-bikes that only have a small motor to assist the rider's pedal-power (i.e., (pedelecs) to somewhat more powerful e-bikes which tend closer to moped-style functionality: all, however, retain the ability to be pedalled by the rider and are therefore not electric motorcycles. E-bikes use rechargeable batteries and the lighter ones can travel up to 25 to 32 km/h (16 to 20 mph), depending on local laws, while the more high-powered varieties can often do more than 45 km/h (28 mph). In some markets, such as Germany as of 2013, they are gaining in popularity and taking some market share away from conventional bicycles, while in others, such as China as of 2010, they are replacing fossil fuel-powered mopeds and small motorcycles. Depending on local laws, many e-bikes (e.g., pedelecs) are legally classified as bicycles rather than mopeds or motorcycles. This exempts them from the more stringent laws regarding the certification and operation of more powerful two-wheelers which are often classed as electric motorcycles. E-bikes can also be defined separately and treated under distinct Electric bicycle laws. E-bikes are the electric motor-powered versions of motorized bicycles, which have been in use since the late 19th century. Some bicycle-sharing systems use them. It turns out that electric bicycles, or "e-bikes," have accounted for a large portion of more recent growth in world bike demand and output, with production doubling from 2004 to 21 million units in 2007.E-bikes Use a battery-powered electric motor to assist riders with pedalling. They can typically go as fast as 15 to 20 miles per hour (24 to 32 km/h) or more. Depending on the country, e-bikes are often classified as bicycles and not subject to the level of regulation or laws that can restrict the ownership and operation of cars and other motor vehicles. Electric bikes require less work on the part of riders and make it easier to negotiate inclines, tolerate biking in hot weather, and, generally, bike under other more strenuous conditions. The Indian industry doles out 1.25 crore bicycles every year - with almost each day witnessing new designs, colours and features. Even as environmentalists and the health-conscious

worry about the rising number of motorized vehicles on our roads, the easy-on-pocket two-wheeled vehicle still pedals its way to almost every Indian household.

Advantages of using E-bike:

1. Speed - Electric bikes generally have a higher top speed than a normal bicycle with the same rider. Most electric bicycles n the United States are limited to a 20 mile per hour top speed, however the rider can pedal to make it go even faster. So this makes it easy for a novice or out of shape rider to get some significant speed going.

2. Great for Commuting - An electric bicycle can require little to no effort to ride. Just twist the throttle and steer the bike where you want to go. This makes it so the rider doesn't have to break a sweat in their work cloths on the way to work. Another huge advantage is the ability to skip the traffic. An electric bicycle can be ridden on a sidewalk, through a park or down an alley allowing it to beat the traffic and in many cases get to a destination faster than a car.

3. Easy on the body - An electric powered bicycle allows riders who are physically less able or out of shape to keep up with younger and more in shape people. We have many customers who order bikes to keep up with the grand children. E-bikes also allow for long comfortable bike rides where the rider doesn't feel exhausted of in any type of physical pain at the end. Just a comfortable ride at a pace the rider enjoys.

4. E-Bikes are cool - Be ready to ask questions to the many curious onlookers that are interested in what you are riding and how it works.

Disadvantages:

1. Complexity - Electric bicycles have more parts than a normal bicycle, so that means more chance of something going wrong. These days the quality of electric bicycles are very good, however whenever there is more complexity, there is the higher possibility of something going wrong.

2. Weight - Electric bicycles add an electric motor, battery and controller among other things, so this about doubles the weight of the bicycle when the battery is installed. This isn't a problem when the battery is charged and the rider is using the electric motor, but it can make it harder to pedal when the battery is out of juice.

3. Batteries Maintenance - It is good to charge your electric bike battery after each ride. It is also important not to let your electric bike used for a long period of time because the battery capacity will fall due to its chemistry. It is best practice to use your electric bike at least once a month to keep the battery in good shape. Electric bicycle batteries don't last forever, a Lithium Ion Battery will last 2-5 years and an SLA battery will last 1-2 years before the cells have to be replaced. However with good battery maintenance you can extend the life of the battery for as long as the bike in most cases.

1.2 Why personal mobility? |

Every mode of transportation has its pros and cons, but here we are talking about electric bicycle as a personal mobility. Riding bicycle has many advantages, that is the reason bicycles are still sustaining as mode of transportation in the busy life style. There are few back side so using personal mobility, yet it can be controlled. Main reason to focus on personal mobility it saves time and more convenient .

1 Personal Bicycle

Pros:
- Convenient.
- Saves time.
- Personalisation.
- No waiting time.
- Ready to use.
- Self sufficient.
- Feasible to move anywhere.

Cons:
- Maintenance.
- Liablity.

2 E-buggy

Pros:
- Cheaper than Auto-rickshaw.
- Less energy consumption in travel.
- No liability.
- Reduce traffic congestion

Cons:
- Less frequency.
- Connectivity is poor.
- Weather protection is not suitable for rainy season.
- Safety issues.
- Speed is slow.

3 Autorickshaw

Pros:
- Consume less to travel.
- Weather protection.

Cons:
- Availability is less.
- Fare is expensive than all other alternative.
- Pollutes college compound.

4 Shared mobility

Pros:
- No liability.
- No maintenance cost.

Cons:
- Availability is less.
- Costly rides.
- Bicycles are not maintained.

Figure 1- Mobility comparative chart

1.3 The aim of the project |

The bicycle offers a more convenient way to go from A to B but it does-not offer a fast and practical solution. Technology is playing a vital role these days where everything is connected via smart phones. It offers hassle free life and focus more on livelihood then worrying about your resources. Projects aim at designing an electric bicycle targeting college student. So that student can travel hassle free from one place to another. It would also enhance the experience of riding an electric bicycle which will be smart, secure and practical. It aims at identifying the need of students on daily basis and trying to put into new design of electric bicycle.

2. Research

2.1 Pre-research |

2.1.1 About electric bicycle

An electric bicycle also known as an e-bike is a bicycle with an integrated electric motor which can be used for propulsion. Many kinds of e-bikes are available worldwide, from e-bikes that only have a small motor to assist the rider's pedal-power (i.e., (pedelecs) to somewhat more powerful e-bikes which tend closer to moped-style functionality: all, however, retain the ability to be pedalled by the rider and are therefore not electric motorcycles. [1]

E-bikes are classed according to the power that their electric motor can deliver and the control system, i.e., when and how the power from the motor is applied. Also the classification of e-bikes is complicated as much of the definition is due to legal reasons of what constitutes a bicycle and what constitutes a moped or motorcycle. As such, the classification of these e-bikes varies greatly across countries and local jurisdictions.

Despite these legal complications, the classification of e-bikes is mainly decided by whether the e-bike's motor assists the rider using a pedal-assist system or by a power-on-demand one.

Definitions of these are as follows:

With pedal-assist the electric motor is regulated by pedalling. The pedal-assist augments the efforts of the rider when they are pedalling. These e-bikes – called pedelecs – have a sensor to detect the pedalling speed, the pedalling force, or both. Brake activation is sensed to disable the motor as well.

With power-on-demand the motor is activated by a throttle, usually handlebar-mounted just like on most motorcycles or scooters.

Therefore, very broadly, e-bikes can be classed as:

E-bikes with pedal-assist only: either pedelecs (legally classed as bicycles) or S-Pedelecs (often legally classed as mopeds)
Pedelecs: have pedal-assist only, motor assists only up to a decent but not excessive speed (usually 25 km/h), motor power up to 250 watts, often legally classed as bicycles
S-Pedelecs: have pedal-assist only, motor power can be greater than 250 watts, can attain a higher speed (e.g., 45 km/h) before motor stops assisting, legally classed as a moped or motorcycle (not a bicycle)
E-bikes with power-on-demand and pedal-assist
E-bikes with power-on-demand only: often have more powerful motors than pedelecs but not always, the more powerful of these are legally classed as mopeds or motorcycles
Pedal-assist only
E-bikes with pedal-assist only are usually called pedelecs but can be broadly classified into pedelecs proper and the more powerful S-Pedelecs.

Pedelecs
The term “pedelec” (from pedal electric cycle) refers to a pedal-assist e-bike with a relatively low-powered electric motor and a decent but not excessive top speed. Pedelecs are legally classed as bicycles rather than low-powered motorcycles or mopeds.

The most influential definition of pedelecs and which are not comes from the EU. EU directive (EN15194 standard) for motor vehicles considers a bicycle to be a pedelec if:

the pedal-assist, i.e. the motorised assistance that only engages when the rider is pedalling, cuts out once 25 km/h is reached, and
when the motor produces maximum continuous rated power of not more than 250 watts

(n.b. the motor can produce more power for short periods, such as when the rider is struggling to get up a steep hill).
An e-bike conforming to these conditions is considered to be a pedelec in the EU and is legally classed as a bicycle. The EN15194 standard is valid across the whole of the EU and has also been adopted by some non-EU European nations and also some non-European jurisdictions (such as the state of Victoria in Australia).

Pedelecs are much like conventional bicycles in use and function — the electric motor only provides assistance, for example, when the rider is climbing or struggling against a headwind. Pedelecs are therefore especially useful for people in hilly areas where riding a bike would prove too strenuous for many to consider taking up cycling as a daily means of transport. They are also useful for riders who more generally need some assistance, e.g. for people with heart, leg muscle or knee joint issues.

S-Pedelecs

More powerful pedelecs which are not legally classed as bicycles are dubbed S-Pedelecs (short for Schnell-Pedelecs, i.e. Speedy-Pedelecs) in Germany. These have a motor more powerful than 250 watts and less limited, or unlimited, pedal-assist, i.e. the motor does not stop assisting the rider once 25 km/h has been reached. S-Pedelec class e-bikes are therefore usually classified as mopeds or motorcycles rather than as bicycles and therefore may (depending on the jurisdiction) need to be registered and insured, the rider may need some sort of driver's license (either car or motorcycle) and motorcycle helmets may have to be worn. In the United States, many states have adopted S-Pedelecs into the Class 3 category. Class 3 ebikes are limited to <=750 watts of power and 28 mph.

Power-on-demand and pedal-assist

Some e-bikes combine both pedal-assist sensors as well as a throttle. An example of these is the eZee Torq and Adventure 24+ by BMEBIKES. The motor on this type of e-bike is activated by pushing the throttle or by pedalling.

Power-on-demand only

Some e-bikes have an electric motor that operates on a power-on-demand basis only. In this case, the electric motor is engaged and operated manually using a throttle, which is usually on the hand-grip just like the ones on a motorbike or scooter. These sorts of e-bikes often, but not always, have more powerful motors than pedelecs do.

With power-on-demand only e-bikes the rider can:

Ride by pedal power alone, i.e. fully human-powered.
Ride by electric motor alone by operating the throttle manually.
Ride using both together at the same time.
Some power-on-demand only e-bikes can hardly be confused with, let alone categorised as, bicycles.

2.1.2 Folding electric bicycle

There are many foldable e-bicycle available world wide. They are widely unpopular in India because of high price and unpopularity. Brief study was done over internet to find out the popular e-bicycle in India as well as international. Few international products are : ARIV by Uber Scuuter Plus, Swagtron Swagcycle Envy, Mi YunBike C1, Stigo
In order to identify the basic architecture and features of E-bike, Detailed study of individual bicycle was conducted to, which is as follows: [5]

Figure 2 Uber Scuuter Plus

1. Uber Scuuter Plus
Go everywhere with your Uber Scuuter. This foldable scooter is primed and ready when walking isn't an option. With a battery range of 27 miles, you'll get where you need to be and fast. This powerful scooter can reach top speeds up to 15 miles per hour.
Weight: 39lbs
Max Load Weight: 264lbs
Unfold size: 3.9ft x 2ft x 3.2ft
Fold size: 4ft x 1.7ft x .88ft
Charge Time: 3-5 Hours
Includes charge adapter rated at 100-240V 50/60 Hz. Use any standard US power outlet to charge.

Figure 3 Swagtron Swag cycle envy

2. Swagtron Swagcycle Envy – Folding Electric Bicycle bike ₹ 54,999

The last e-Cycle on my list is slightly different. However, it can be a very practical bike for a few people. This bicycle can be folded. It is very light and can be carried easily.

Do note, that bicycle is smaller compared to your regular bicycles. Have a look at the images below for reference. [6]

If you are on the slightly heavier side, I do not suggest buying this bike for you. (The manufacturer says that it will take a load of 120 Kgs. However, you will find it difficult to ride it as your weight increases)

Key Features:

- The bike is really nicely made. The mechanism to fold the handlebars is really smooth and easy to use.
- It has two-foot rest near the front wheel.
- The range of the bicycle on a full charge is around 14 km. It takes around 4 hours to charge this bicycle fully.
- The bicycle weights around 19 kgs
- The bicycle comes equipped with a LED light in the front and a bell.

Figure 4 Mi YunBike C1

2. Mi YunBike C1: The first electric bike, specially designed for young people.Optimization of electrical appliances, high degree of integration, compact placement of the battery, controller and Electronic Control Unit (ECU). Therefore, if you have a desire to disassemble the bike, it will not make much trouble.Yun Bike C1 has a built-in three-axis accelerometer and three-axis gyroscope; if you need to go downhill, smart bicycle system determines places where you need to put more effort and automatically supplies electric power, so you can effortlessly ride up the hill. [7]

Product Overview

- Powerful 250W front-hub motor
  Throttle
  LCD display with speed, range, trip meter, odometer
  V-brakes
  7-speed Shimano Acera gears
  38 lbs
  Folding Size: 30” x 24” x 16”(LxHxW)
- Sizing
  13” seat tube & 16” x 1.75” tire
  Recommended rider: 4’8” – 6’2”
- Battery
  Panasonic Lithium-Ion cells 8.8aH Battery
  Centrally placed battery for low center of gravity means a more stable and safe ride
  Battery can be removed or locked on bike with key
  Charger included, 2-3 hours required for full charge

Figure 5 Stigo bike

3. Stigo was developed in response to the need expressed by many urban commuters for an electric bicycle or scooter. While it's not a speed demon that you'll need motorcycle license to legally ride around, the Stigo isn't a push over either. The 250W hub motor equipped electric scooter can still top out at a speed of 15 miles per hour. With a 36V LiFePO4 battery on board, it's possible to cruise up to 24 miles on a single charge.[8]

- FOLDABLE ELECTRIC BIKE WITH SEAT - Stigo S is a perfect foldable urban electric vehicle for active men and women. Ergonomical design ensures less stress on your muscles and joints due to the equally distributed bodyweight. This reduces pressure on your back and knees.
- SAFE & TRUSTWORTHY – Stigo S folding electric bike is built by highest quality norms. We focused on a strong frame, quick breaking system, bright headlights and loud horn. You can monitor battery level straight from the handlebar. WARRANTY – All Stigo electric bikes for men and women have warranty and after-service in US.
- LONG RANGE – Ride Motorized Stigo E-bike for 9-13 mi on a single charge while going up to 16 mph. Average electric bike user rides approximately 5mi per day. Stigo electric scooter for adults with seat has similar charger as laptops do, so you can charge your electric road bike from any output.
- STORE INDOORS – Since it only takes two seconds to fold your Stigo, you can take your foldable electric scooter bike indoors (home/work/café/boat). Stigo is placed in an upright position, which means its small and doesn't take much more room than an average vacuum cleaner.
- COMFORTABLE SEAT – Stigo electric bikes for adults seat is in a proper sitting position that supports healthy S-shaped spine. The horizontal seat prevents you slipping forward. For your maximum comfort, we have designed a seat that is wide enough to support you from all angles.

2.1.3 Study of E-bike components

Internet study was conducted to find out the basic requirement for E-bike. This was done to identify the basic components:

All these system have following components in common:

1. Motor: Brushless DC electric motor also known as electronically commutated motors, or synchronous DC motors, are synchronous motors powered by DC electricity via an inverter or switching power supply which produces an AC electric current to drive each phase of the motor via a closed loop controller.
2. Controller: A motor controller is a device that works alongside a micro-controller, the batteries and motors. Most controllers have under-voltage, over-voltage, short circuit protection, current limit protection, thermal protection and voltage transients. Without these protections, the motor is exposed to threats that can result in permanent electrical or mechanical damage
3. Battery: Battery are power house, store power in form of chemical energy. There are many types of battery available, few of them are Lead acid, Lithium polymer, Lithium ion batteries.
4. Battery charger: Battery charger is required to charge battery. It can be on board or off board.
5. Display module: Display unit is used to indicate useful information to rider.

Figure 6 1000Watt DC motor with throttle and controller

Figure 7 1000 watt Hub BLDC motor

2.1.4 Motor study

Selecting the motor for the drive is one of the most crucial parts of the architecture as it will define the speed, load carrying capacity and duration for which vehicle can work on every charge.

The two basic type of motors i.e. AC motors and DC motors were compared first. Both have their benefits and limitations and are suitable for different kind of applications here, where we need to maintain low speed and higher efficiency with enough power to easily manoeuvre over high grades and rough terrains DC motor seemed to be the suitable one. DC motor has different benefits over AC motor like better low-end torque and higher peak efficiency. There are different kind of DC motor available like hub Brush less DC motor (BLDC), Brushed DC motors etc. Hub mounted Brushless DC motor is advantageous as it eliminates transmission, service cost and weight. Motor is directly mounted on hub along with braking system.

Considering the weight of vehicle and pulling capacity, following specifications of motor is selected:

Power rating: 250watt BLDC

Figure 8 Lipo battery pack contstruction

Figure 9 Lipo Battery

Figure 10 Lipo Cell

2.1.5 Battery study

To find the suitable type of battery for the required purpose, four most commonly used batteries for the automotive field were compared viz. Molten-salt (Na-NiCl2), Nickel Metal Hydride (Ni-MH), Lithium Sulphur (Li-S) and Lithium Ion (Liion).

Molten salt batteries offer the lowest energy consumption and also has a low price but they have the drawback of having a very narrow band of working temperature where they perform well. Hence, it's an extra work to maintain the right working temperature for the batteries. Whereas, Nickel metal hydride does not have any such conditions but have the lowest energy density, power and are heavy too making them unsuitable for the use in automotive applications. On the other hand, Lithium-sulfur offers many good properties like low weight and good energy storage capacity but has the drawback of being the highest energy consumption making them not suitable for the automotive field as sometimes vehicles tend to stand still for days before they are used again. Lithium-Ion whereas offers moderate energy consumption but has many other beneficial properties like increased life cycle, high energy storage capacity, low weight and continuously decreasing price. All these properties make it the suitable one to be used for the vehicle.

Battery- Lithium ion:

- Voltage of one battery : 3.6 volt
- Rated capacity of one battery : 2.2 Ah
- Charge or discharge current I : 2.2 A
- Charging time: 1hour
- No. of battery in series: 10
- no. of battery in parallel: 20
- Voltage of the storage system: 36v
- Current of the storage system: 6 A
- Capacity of the storage system (energy stored): 3.9kWh

2.1.6 Material study

Figure 11 Aluminium tube

A. **Aluminium** is remarkable for its low density and its ability to resist corrosion through the phenomenon of passivation. Aluminium and its alloys are vital to the aerospace industry and important in transportation and building industries, such as building facades and window frames. The oxides and sulfates are the most useful compounds of aluminium.

Advatanges:

1. Aluminium has the highest strength-to-weight ratio of any metal.
2. Aluminum is 100% recyclable without losing any of its natural characteristics.
3. Aluminum can be easily colored by anodization, and holds paint extremely well. Aluminum can be finished in various ways.

Disadvantages :

1. Aluminum requires special processes to be welded.
2. It is abrasive to tooling, or more accurately, the aluminum oxide coating that forms upon it is.
3. It is more expensive than steel.

Figure 12 Steel tube

B. **Steel**: Steel is an alloy of iron and carbon, and sometimes other elements. Because of its high tensile strength and low cost, it is a major component used in buildings, infrastructure, tools, ships, automobiles, machines, appliances, and weapons.

Advantages:

1. High strength/weight ratio. Steel has a high strength/weight ratio. Thus, the dead weight of steel structures is relatively small.
2. Ductility. As discussed in the previous section, steel can undergo large plastic deformation before failure, thus providing large reserve strength.
3. Predictable material properties. Properties of steel can be predicted with a high degree of certainty.
4. Speed of erection. Steel structures can be erected quite rapidly. This normally results in quicker economic payoff.

5. Quality of construction. Steel structures can be built with high-quality workmanship and narrow tolerances.
6. Adaptation of prefabrication. Steel is highly suitable for prefabrication and mass production.

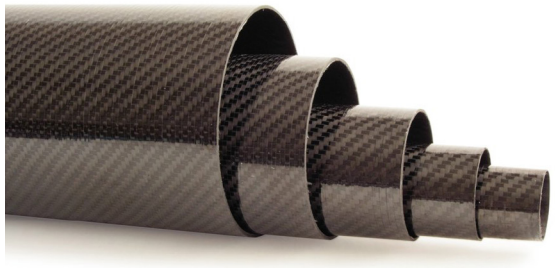


Figure 13 Carbon Fibre tube

C. **Carbon fibre**: Carbon fibers or carbon fibres (alternatively CF, graphite fiber or graphite fibre) are fibers about 5–10 micrometres in diameter and composed mostly of carbon atoms. Carbon fibers have several advantages including high stiffness, high tensile strength, low weight, high chemical resistance, high temperature tolerance and low thermal expansion. These properties have made carbon fiber very popular in aerospace, civil engineering, military, and motorsports, along with other competition sports. However, they are relatively expensive when compared with similar fibers, such as glass fibers or plastic fibers.

Advantages:
Carbon is stiffer and stronger, generally, though some specialized high-strength glass, like S2 glass, is almost comparable in strength on a volume basis. Carbon is also lighter for the same volume of material. Carbon composite parts therefore tend to be much lighter than glass composite parts.

Disadvantages:
Glass stretches more before it breaks, so it's more useful for really flexible applications, like skis and snowboards, and helicopter blades. This ability to stretch also makes glass better suited for really high impact damage, like ballistics (bullets hitting your glass or carbon part, though presumably not your snowboard). Carbon fiber is roughly 8X-15X more expensive than glass per weight.

2.2 User study |

Objective of exercise was to identify the need and problems from users point of view.
Target audience: Interview was done with IIT students who travel with any mean of transportation(E buggy, bicycle,etc). The intent of this study was to find out the problem they come across.

Questionnaire:
Name and gender.
How much you travel daily (average)?
What and how much do you carry with yourself?
What are the activities do you do in your bicycle (shopping, daily commuting,etc)?(If applicable)
What problems do you face in your bicycle(for examples: parking,storage,rainy season etc)? (If applicable)
What was your budget for bicycle? (If applicable)
What speed do you like while riding your bicycle? (If applicable)
How do you perceive a electric bicycle?
If you own a bicycle or any personal vehicle, what happens to it when you graduate from college?

Scenario was considered to identify which scenario is most common among target audience.
Scenario-1: For daily commute to college from hostel to lecture hall. Where they carry bag pack and all academics essentials (book,stationery,etc).
Scenario-2: For commute to gymkhana with the sports kit.
Scenario-3: Can be used to go to local grocery shop, shopping mall, etc.

2.2.1 Interviews

Enlin: I drive bicycle because of rule in college plus it is eco friendly mode of transportation. Drive bicycle all time. I travel bicycle on an average 7kms. Carry rain coat during rains, water bottle, badminton racket, tennis racket and balls. Sometimes carrying racket on backpack hits my head when I sit up straight. Sometimes carrying sweater and everything makes backpack heavy, when I doing internship. Problems in finding cycle when I park outside. Inside human powered vehicle is ok but I need powered mobility to go out. Suitable position of bag for me is middle and rear. Sometimes I carry more stuffs to lab when I do project.

Daily average distance travel: 7kms.

Maximum speed: 10kmph

Vehicle cost: 12000 INR

Bagpack: 32litres

Nirmal: I ride bicycle on an average 4 kms. Carry laptop bag , gym bag and raincoat. Carry models sometimes. I find difficulty in finding my bicycle when I park in my hostel or any where in campus. Multiple place to find cycle creates issue. Sometimes cow in parking space pushes the cycle and cycle gets cluttered. If we have a proper parking space inside room i can park inside my room. I feel uphill electric assist is good. Talking about budget I can buy a product if it is good product. I have also used zoom pedal, sharing is good but cycles are ill maintained. I also think institute should provide mobility solution.

Daily average distance travel: 4kms.

Maximum speed: 10kmph

Vehicle cost: 7000 INR

Bagpack: 30litres

Apurba: I have a geared cycle, i dont drive it now. I have issues with falling down. I would prefer dual option for powertrain. Every clothing attire doesn't go with the bicycle, when i wear plazzo i have to be very careful. I can't carry all type of bag when i ride in cycle. Sling bag, side bags are difficult to carry in bicycle. I feel mirror is important . rusting is another issue i feel. 10k is the maximum budget for me.

Daily average distance travel: 5kms.

Maximum speed: 8kmph

Vehicle cost: 10000 INR

Bagpack: 20litres

Minu: I have a non geared bicycle, i ride it everyday. I ride it for almost 4 kms regularly. It is time saving and convenient for me .I strictly need a storage area but not in front. I frequently go out and buy stuff, there i take my bicycle. Sometimes I forget where i have kept my bicycle. I search for it. For me hybrid system is good and i can afford upto 10k.

Daily average distance travel:4kms.

Maximum speed: 10kmph

Vehicle cost: 10000 INR

Bagpack: 20litres

2.2.2 Observation study

Figure 14 - Crowded and unorganised parking

Figure 15 - Security issues

Figure 16 - Bicycles parked anywhere

Figure 17 - Practical space not available

Figure 18 - Parking on road reduces road width

Figure 19 - Abandoned bicycles

Figure 20 - Crowded bicyel parking at hostels

Figure 21 - crowded parking of cycle on main road

2.2.3 Ergonomic consideration

Body dimension

To design motorised vehicle for paraplegic, the study of basic Indian anthropometric data was carried out which helped to set the basic parameters for the design. Measurements of popliteal height from ground, buttock-popliteal length were taken from 5th percentile female and rest of the measurements were taken from the 95th percentile male. Taking knee height and buttock-knee length from 95th percentile male ensures that the handle position will be such that it won't obstruct when used by any tall person. Using popliteal height and buttock-popliteal length of a 5th percentile female insured that it won't be uncomfortable for any short person to use the device. The most comfortable way to sit while riding is the upright position where backbone is close to perpendicular to the seat.

Selected structural body dimension (mm)		
Body features	95th percentile male	5th percentile female
height	1865	1515
Sitting height,erect	901	738
Cervical trunk	667	531
Mid shoulder	630	499
Shoulder breadth	479	349
Hipbreadth	406	269
Popliteal	466	374
Buttock-popliteal	509	394
Elbow height	268	150

[Reference: Indian Anthropometric Dimensions(For Ergonomic Design practice) by Debkumar Chakrabarti]

2.2.4 Riders triangle development

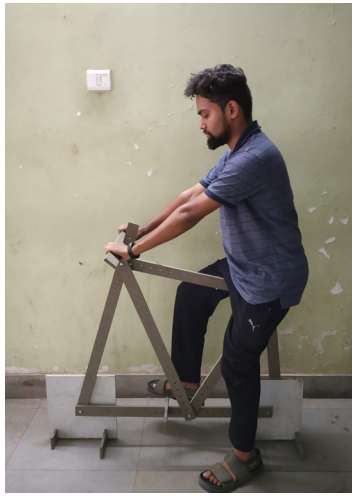
Aim: Objective of the experiment was to identify the riders triangle for comfortable riding position.

Methodology: Users were selected with different height and a kit was made to identify the riders triangle.

Kit: kit seat height was adjustable in a plane and handle bar was adjustable height-wise and foot peg was adjustable longitudinal direction

Figure 22 - Kit

Male, 5ft 4inches



Male, 5ft 6inches

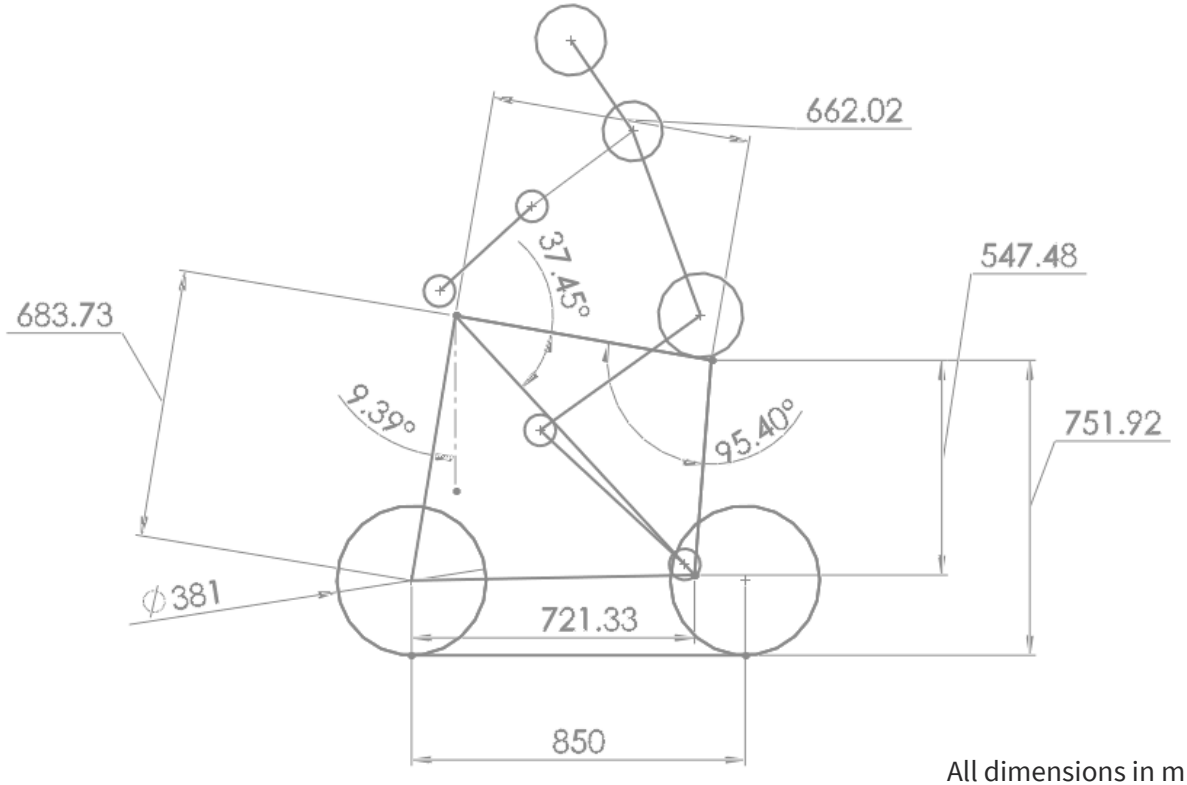
Male, 5ft 6inches

Male, 6ft 3inches

Female, 5ft 3inches

Most commonly found configuration

- Finalised riders triangle was made from the experiment and it is used to ideation.
- Riding position was selected to have comfortable ride.



All dimensions in mm

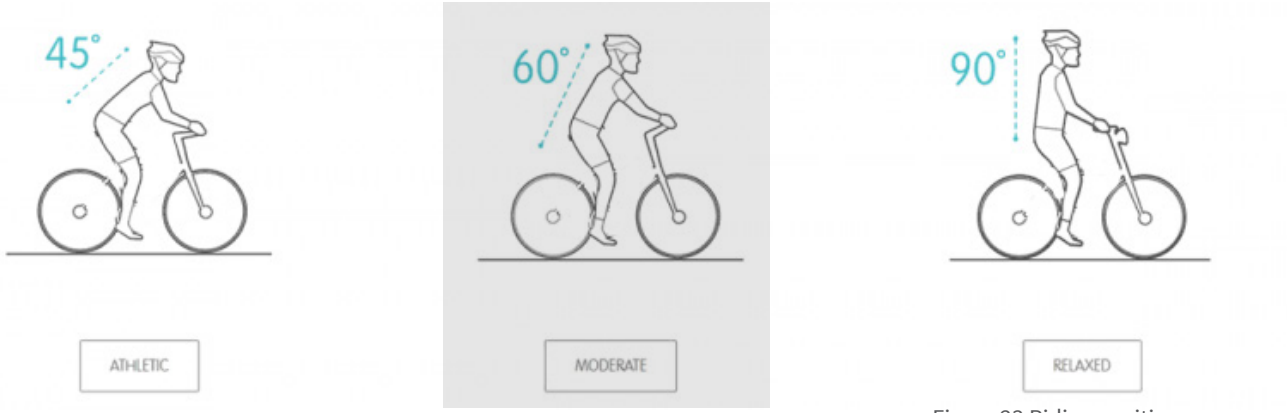


Figure 23 Riding position

2.2.5 Insights

- **80 percentage of students** have personal bicycle, percentage have increased after tumtum service was discontinued.
- Student desire to take back bicycle after graduation.
- Having personal mode of transport(Bicycle) is **Time saving and Convenient.**
- **Parking and unable to locate bicycle** was found to be the most common issue.
- Most of the users are comfortable in keeping their device near or inside room.
- Most of the users **need a practical storage area** in their commute vehicle.
- Users are also concerned about **security of their bicycle.**
- Users don’t appreciate shared mobility because of ill maintained bicycles and high charges, they use it when they don’t have option.
- Most of the students travel at **cruising speed of 15kmph.**
- **20-30 litres with 2-3 kgs** students carry everyday.
- 8 kms is average distance travelled by students on daily basis.

3. Brief

Design brief |

To design a foldable electric bicycle for college students who stay inside campus. The new design will enable users to ride a full size fit foldable electric bicycle which will be easily parked in small space. It will easily transported in car. It will have electric propulsion which will enable effortless and seamless ride. The new design will hold 30-35 litres of bag-pack.

Design intent:

- Full size fit Electric bicycle.
- Light weight and foldable design.
- Safe and secure ride options.
- Theft control.
- Hold 30-35 litres bag-pack.

Technical specification:

Maximum load: 110kgs
Range: 20kms per charge
Weight: less than 15kgs
Max speed: 20kmph
Wheel size: 14 inches wheel size

Motor: BLDC hub motor
Power: 250 watt
max Voltage: 36volt

Battery: Lithium polymer
Power: 3.9kWh

4. Ideation

The ideation phase began by identifying different folding mechanisms. The feasibility of mechanisms was found out by making wire frames mock-up for the same. Later to Acrylic models were generated to check the feasiblity of mehanism. Main aim for doing the exercise was to identify right folding mechanism and its feasibility.

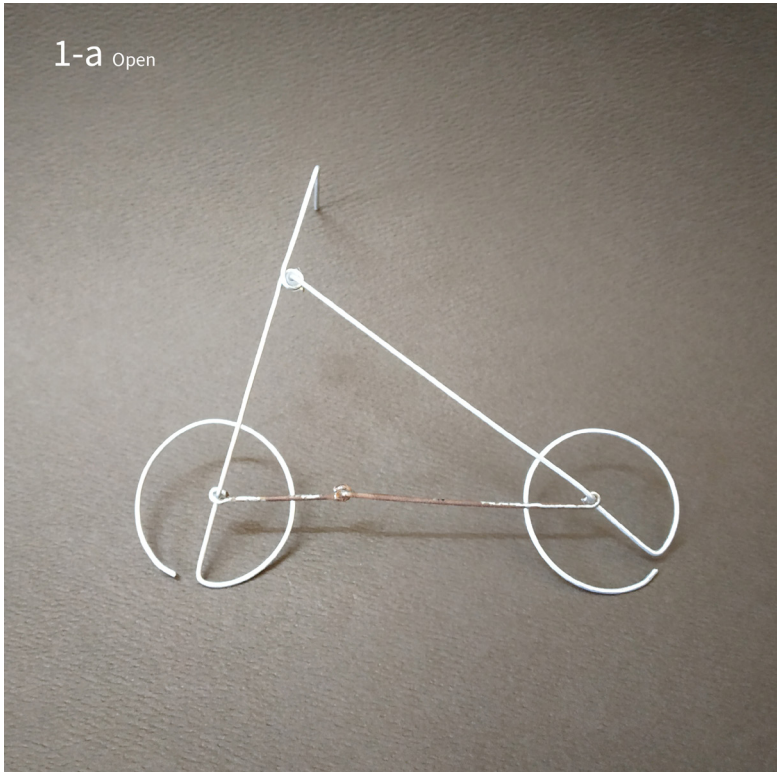


Figure 24 Open

Figure 25 Folded

This wire-frame has single stage folding and it has linear folding mechanism. The wheel comes in tandem to each other making the folding much linear, good to store in room.

Figure 26 Open

Figure 27 Folded

This wire-frame has two stage folding mechanism. Here wheels comes parallel to each other and can be pulled while walking. It has integrated seat on frame.

Figure 28 Open

Figure 29 Folded

This Wire-frame has single stage folding mechanism. Wheels come tandem to each other ad seat integrated.

5. Concept generation

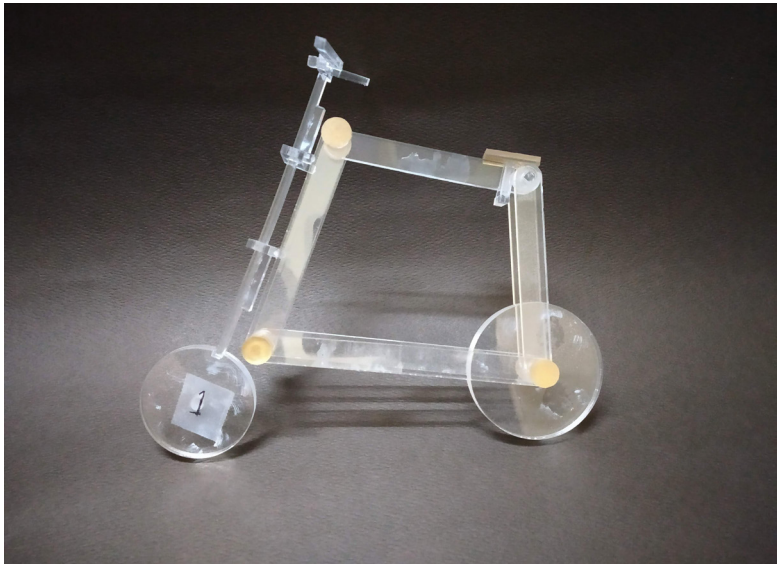


Figure 30 Open

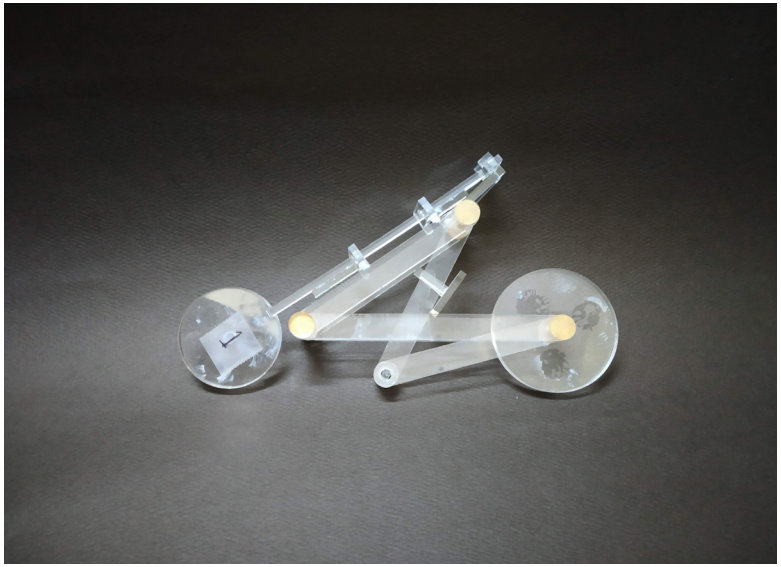


Figure 31 Folded

This idea has two stage of folding. First seat slides on the frame and then seat tube folds to give linear fashion folding. Handlebar folds to down-ways to make it more compact. Rear wheel has hub-motor to make it motorised. Battery pack is attached to lower frame. Middle portion can be used to store bags.

Figure 32 Open

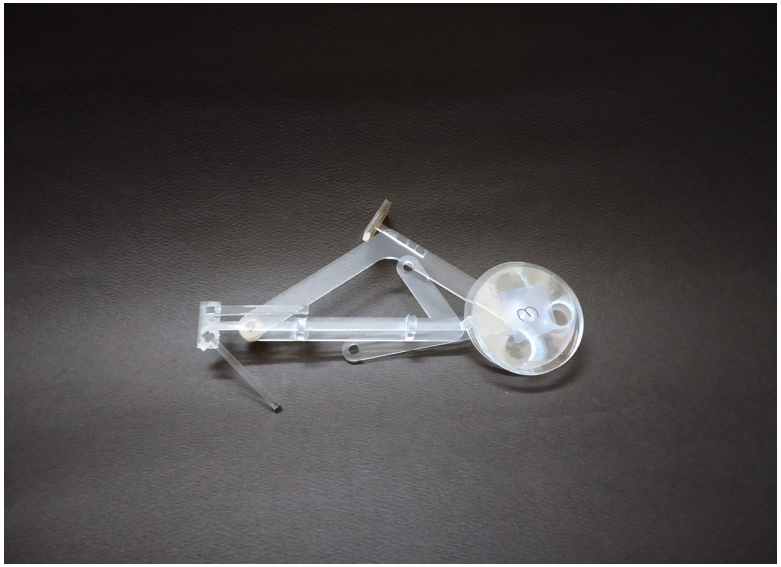


Figure 33 Folded

It is single stage folding mechanism idea. Saddle is fixed to frame and lower tube is split in half to fold the frame pivot at front. Handle bars can be folded in half. Wheels can be aligned side by side and can be pulled. Middle portion can be used to store bag packs.

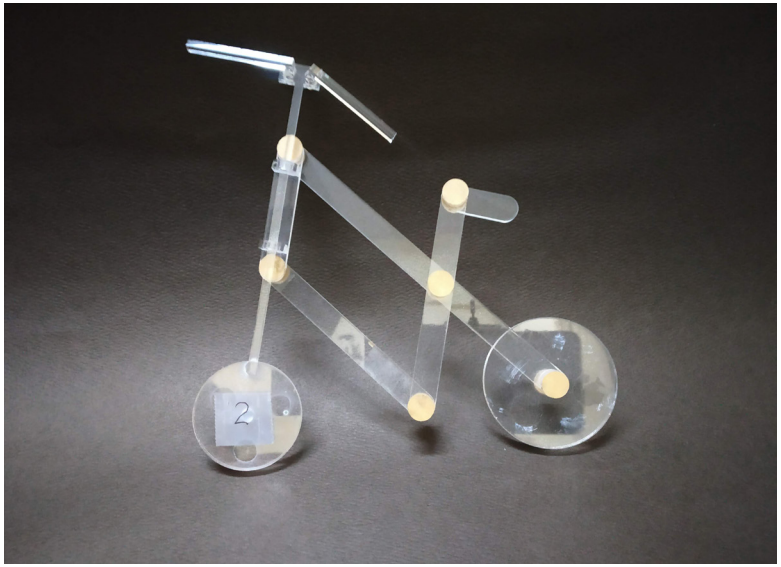


Figure 34 Open

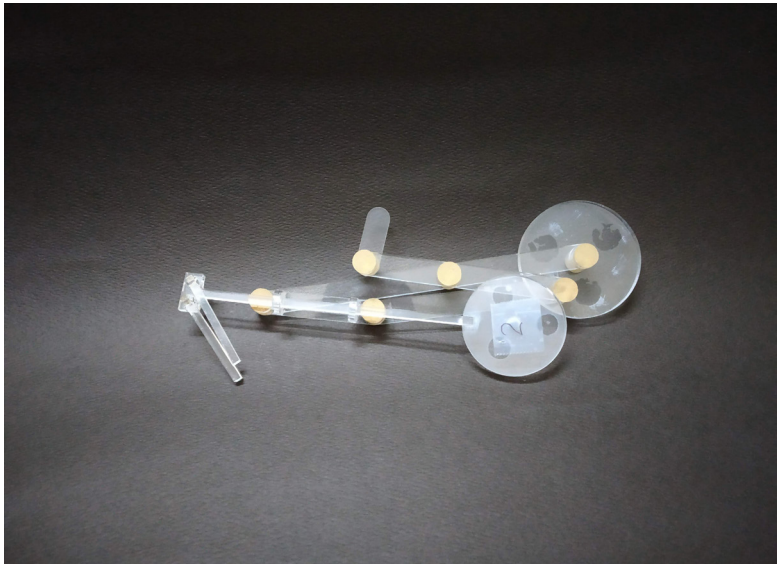


Figure 35 Folded

This is single fold scissor mechanism. Saddle and foot pegs are held at joining axis. Rear has hub motor and front wheel is free wheel. Handle bar can be folded in half to make it more compact. Middle portion in between the mechanism can be used to store bags.

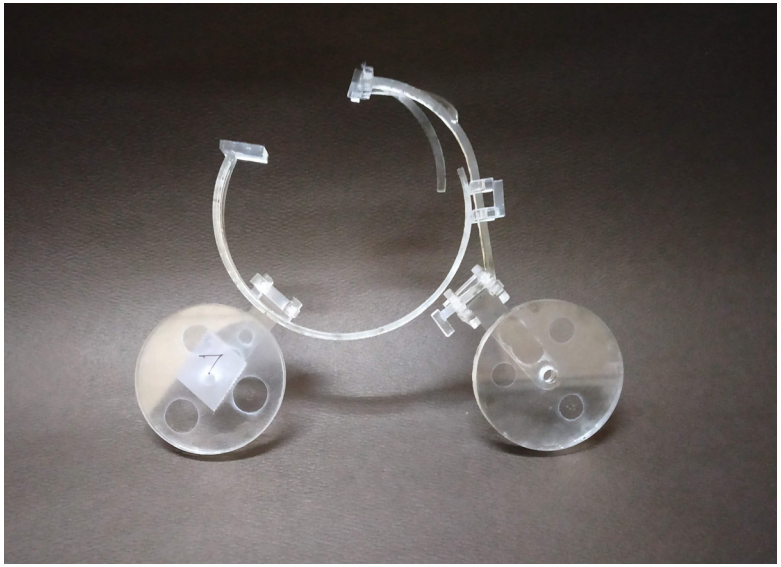


Figure 36 Open

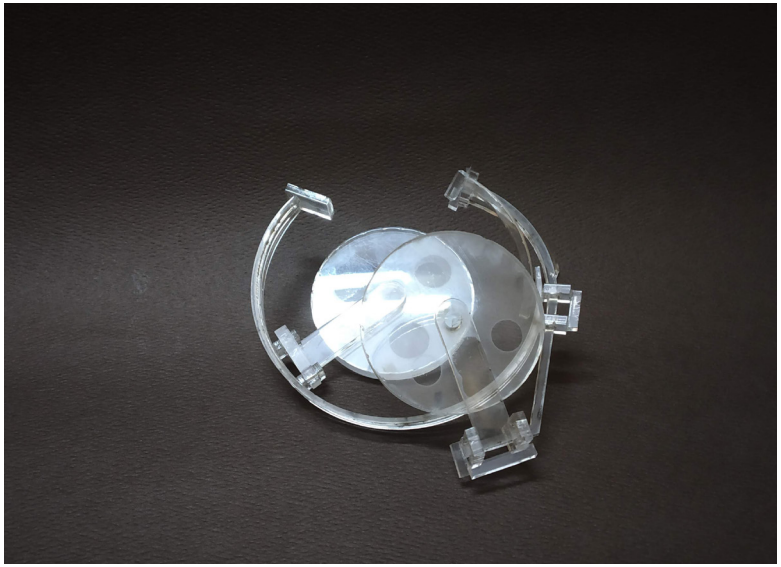


Figure 37 Folded

This is open circular frame where in end has saddle and other end has handle bar. Both wheels can be folded inside the frame to make it compact and portable. Handle bars can be folded the frame. Middle portion can be used as storage area for bag-packs.

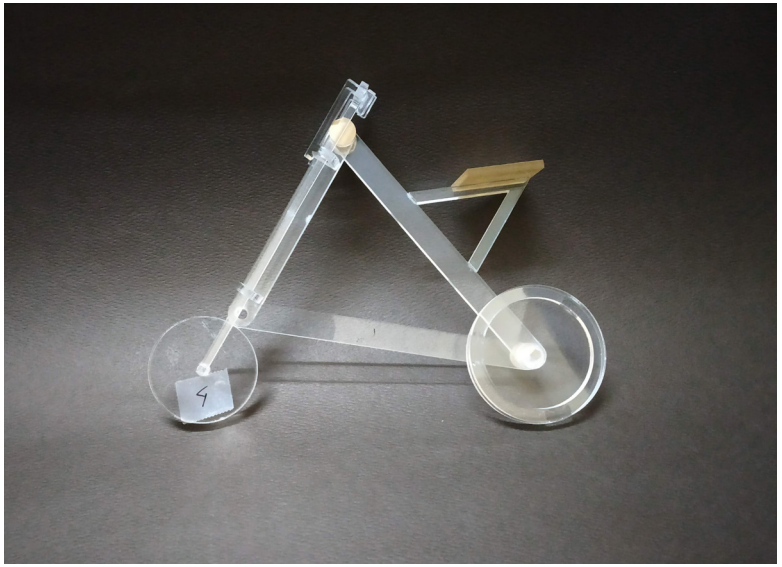


Figure 38 Open

Figure 39 Folded

This idea has two stage fold. Upper pivot near handle bar is acting as pivot. Saddle is fixed in inclined member and handle bar can be folded in half. Lower member is acted as flexible member which holds the frame rigid while riding. Rear wheel has hub motor and while in folded position front wheel concentrically fits rear wheel.

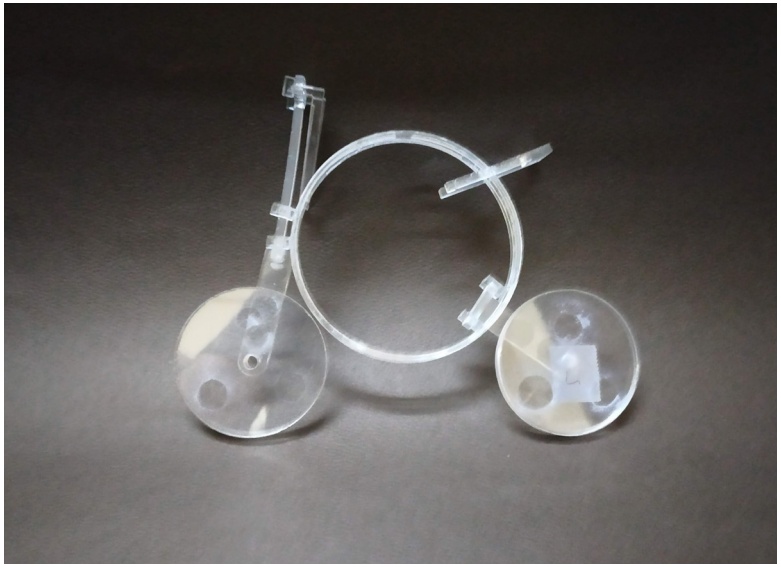


Figure 40 Open

Figure 41 Folded

This idea has full circular frame with sliding saddle. It has 3step folding. Two folds are for front and rear wheel. Last one is for handle bar. Inner space can be used to storage bag-packs. Rear wheel has hub motor.

Figure 42 Open

Figure 43 Folded

This idea has to symmetric frame which folds on one another. Seat holds at rear and handle bar folds in half. It is single stage of fold mechanism. Rear wheel has hub motor and front area is used for storage.

6. Concept evaluation

Concept evaluation was done to identify one direction.



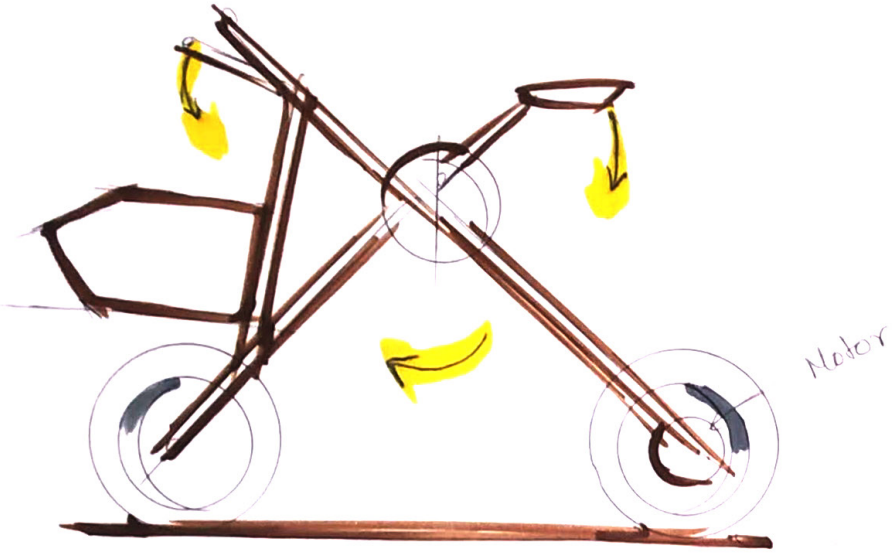


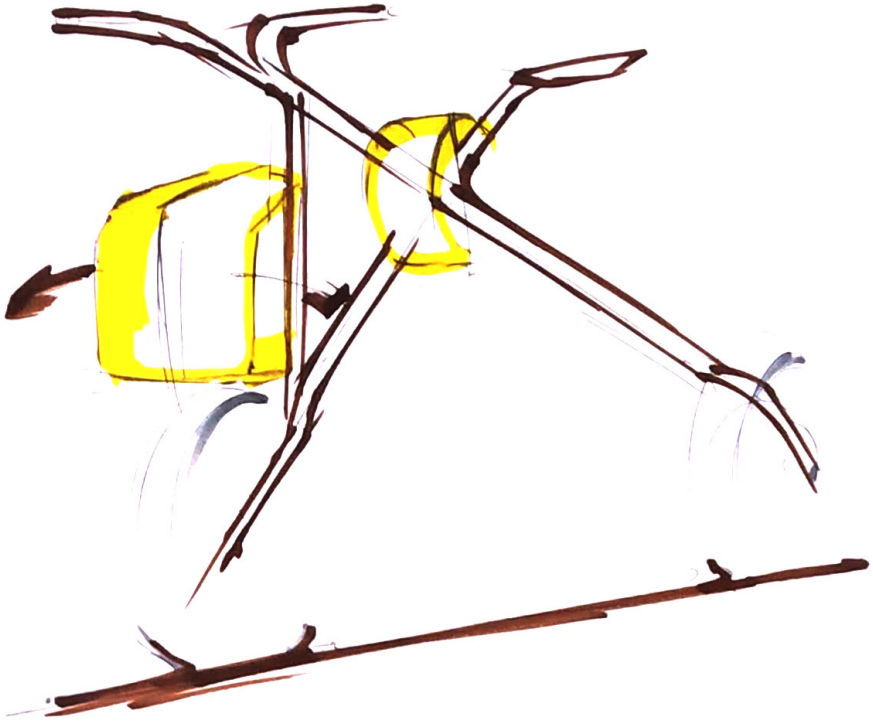


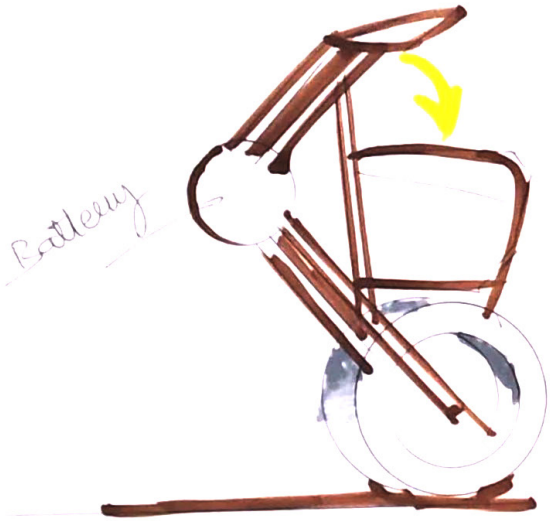
Criteria	Weightage		Concept-1	Concept-2	Concept-3	Concept-4	Concept-5	Concept-6	Concept-7
Ease of folding	45		3	4	3	3	3.5	4	4
Manufacturability	35		4	4	4	4	4	3	4
Unisex	20		1.5	3.5	3	3.5	3.5	4	4
Total	100								
		Total score:	8.5	11.5	10	10.5	11	11	12
		Ranking:	7	2	6	5	4	3	1

Rating
1
2
3
4
5

7. Concept development

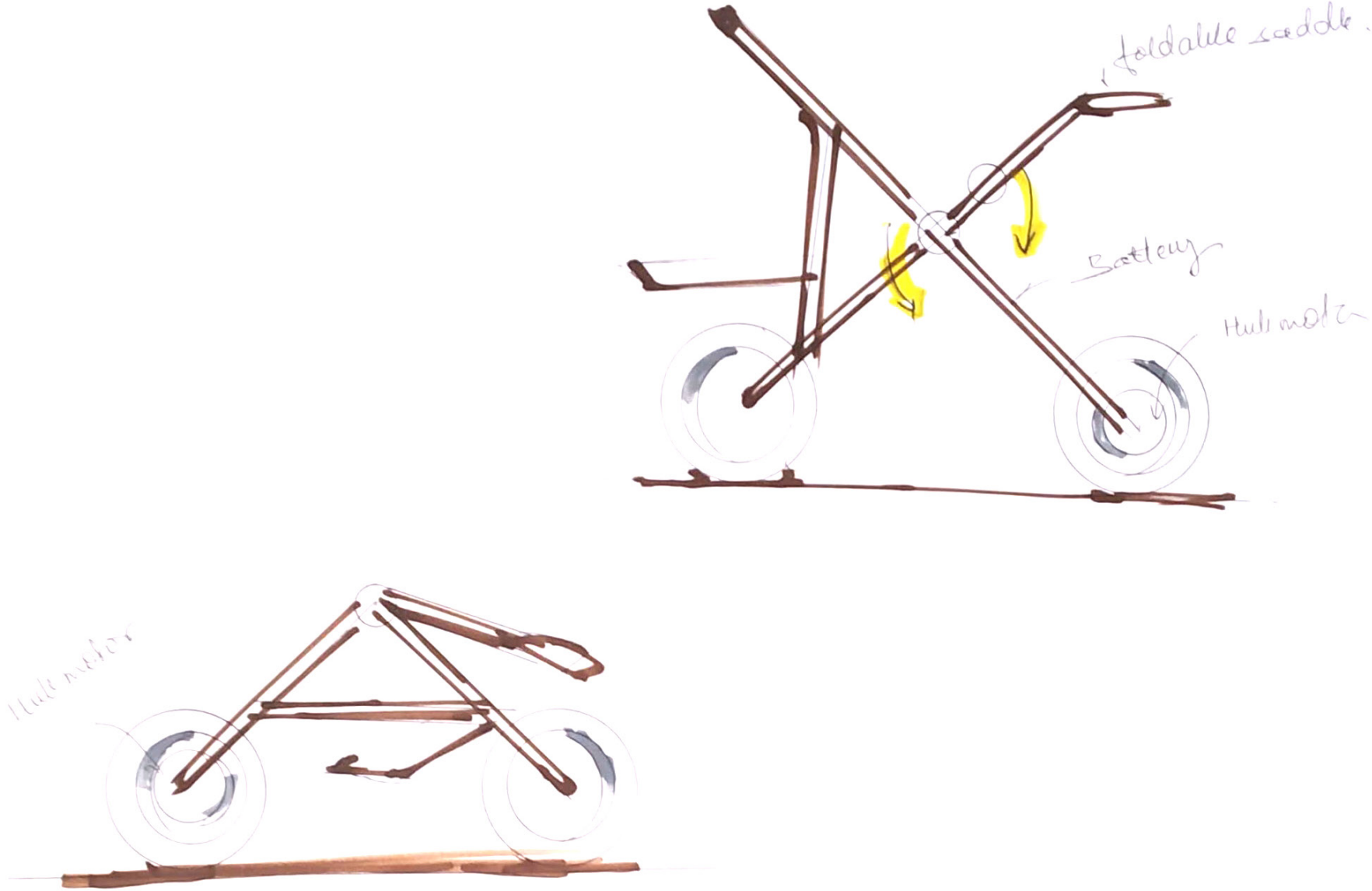

Motor



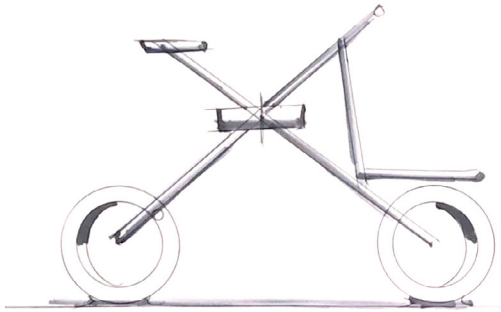

Battery

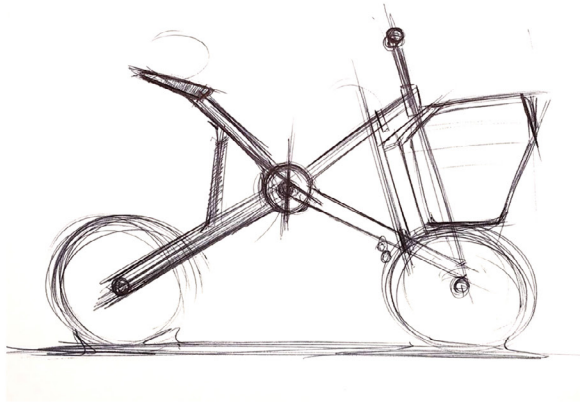

collapsible
Hand
BLDC motor

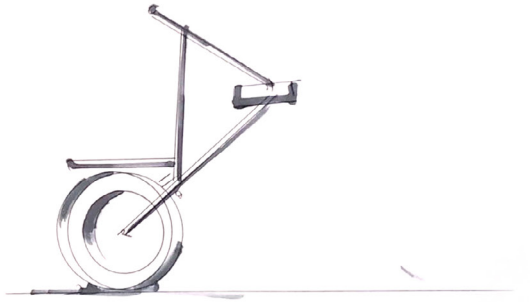

fixed basket

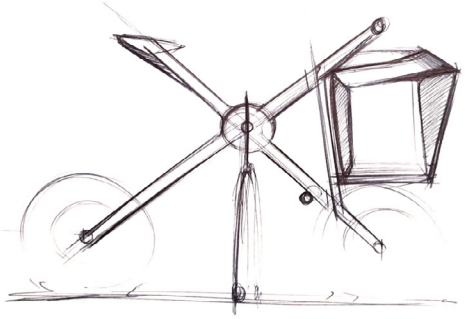

foldable saddle.
Battery
Hub motor
Hub motor

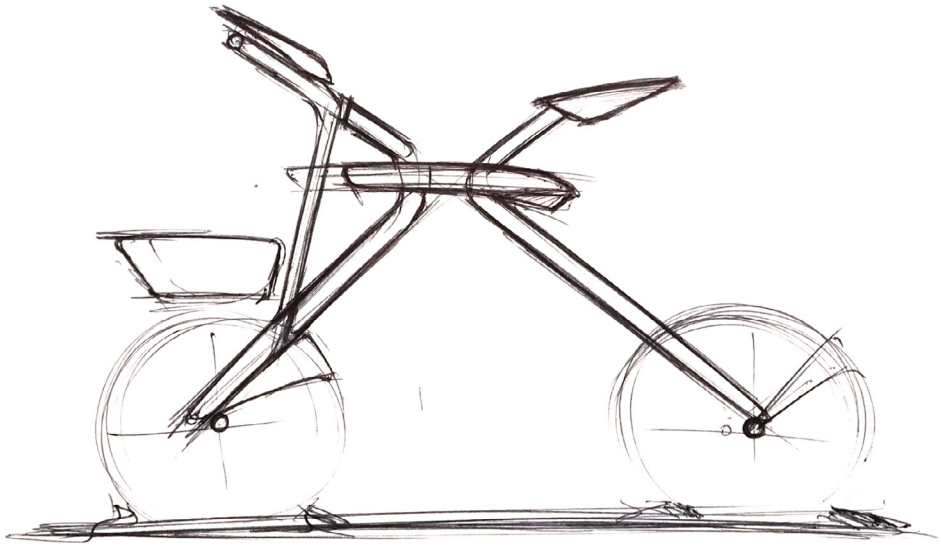
7. Final Concept

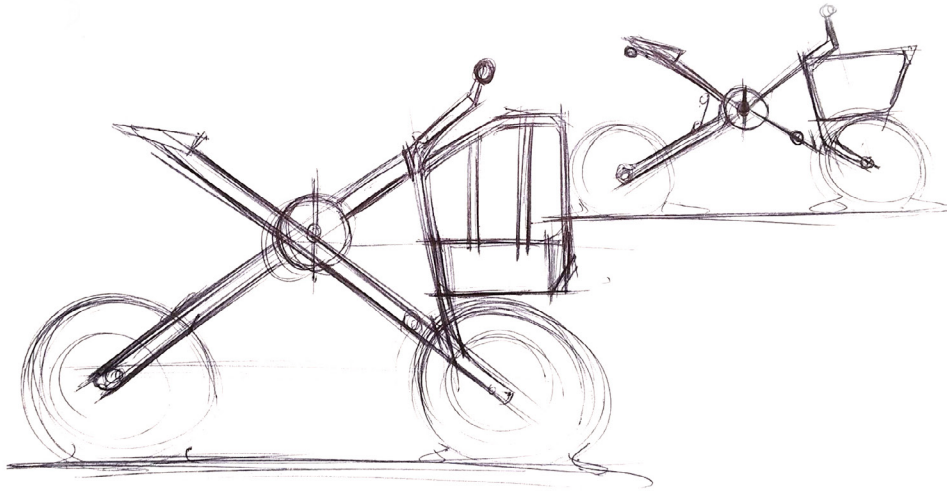


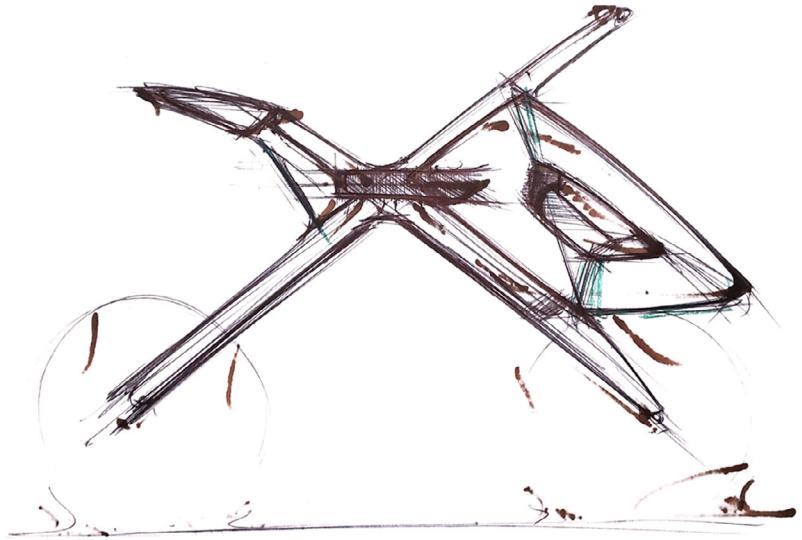


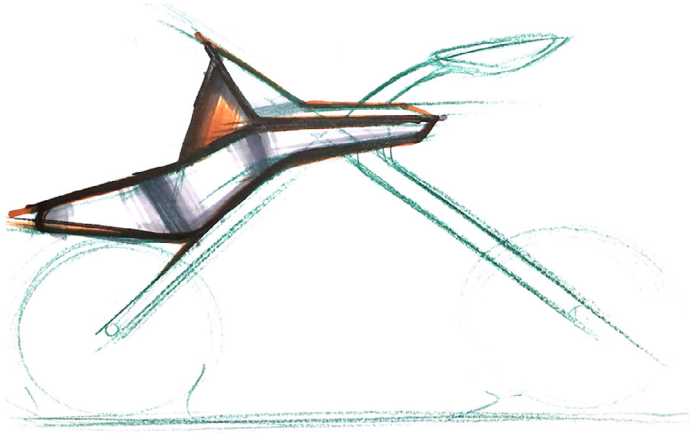


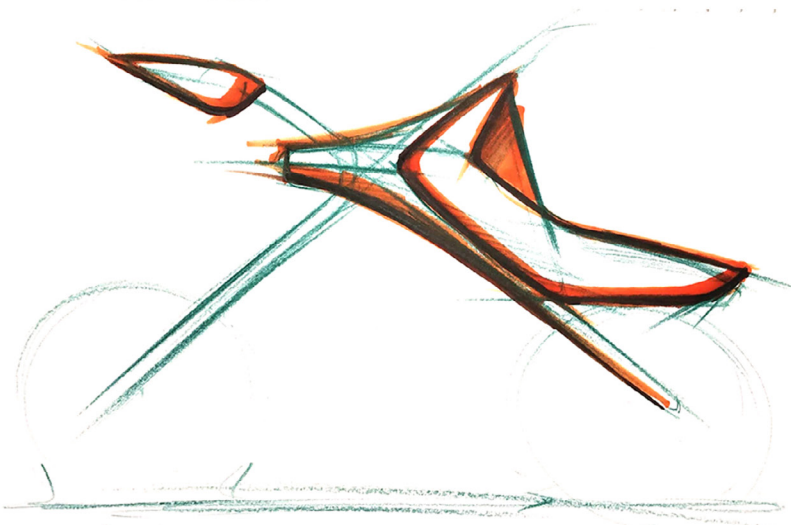


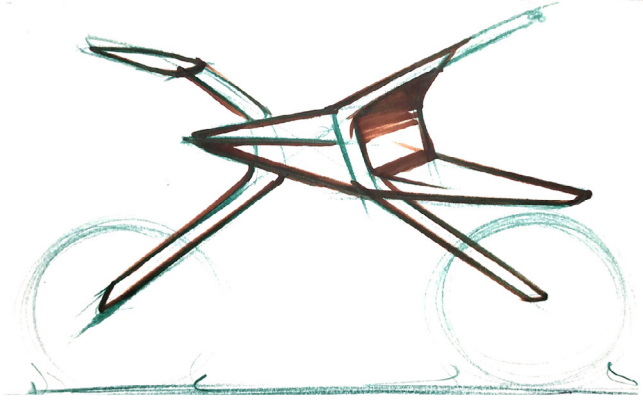


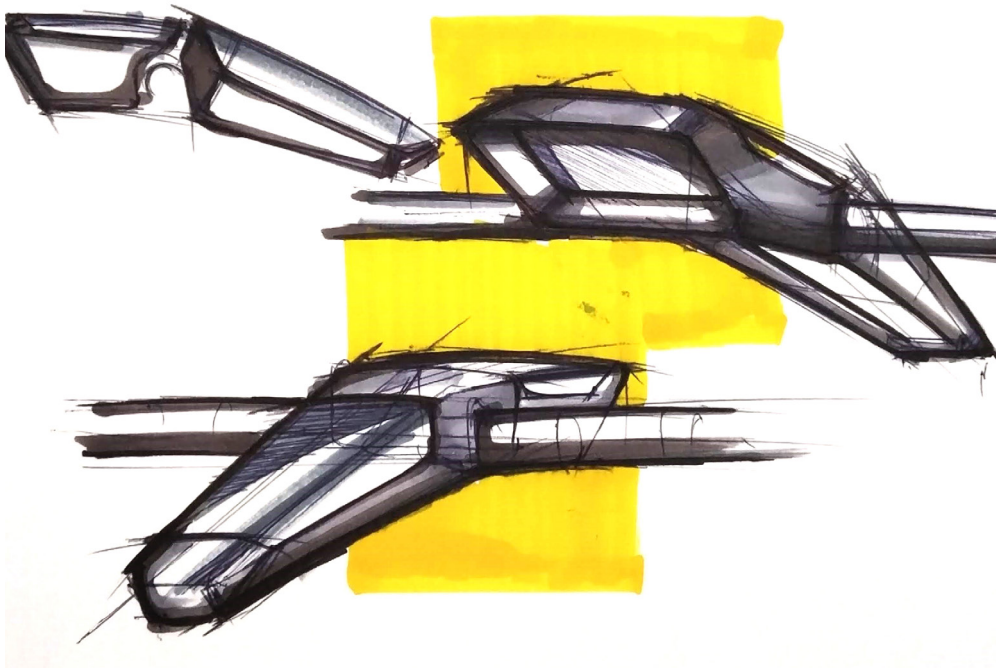


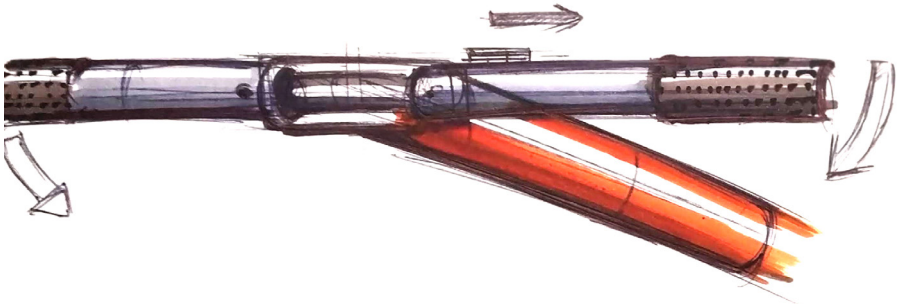


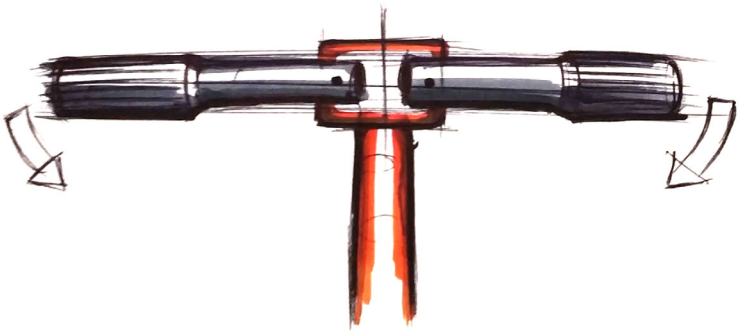


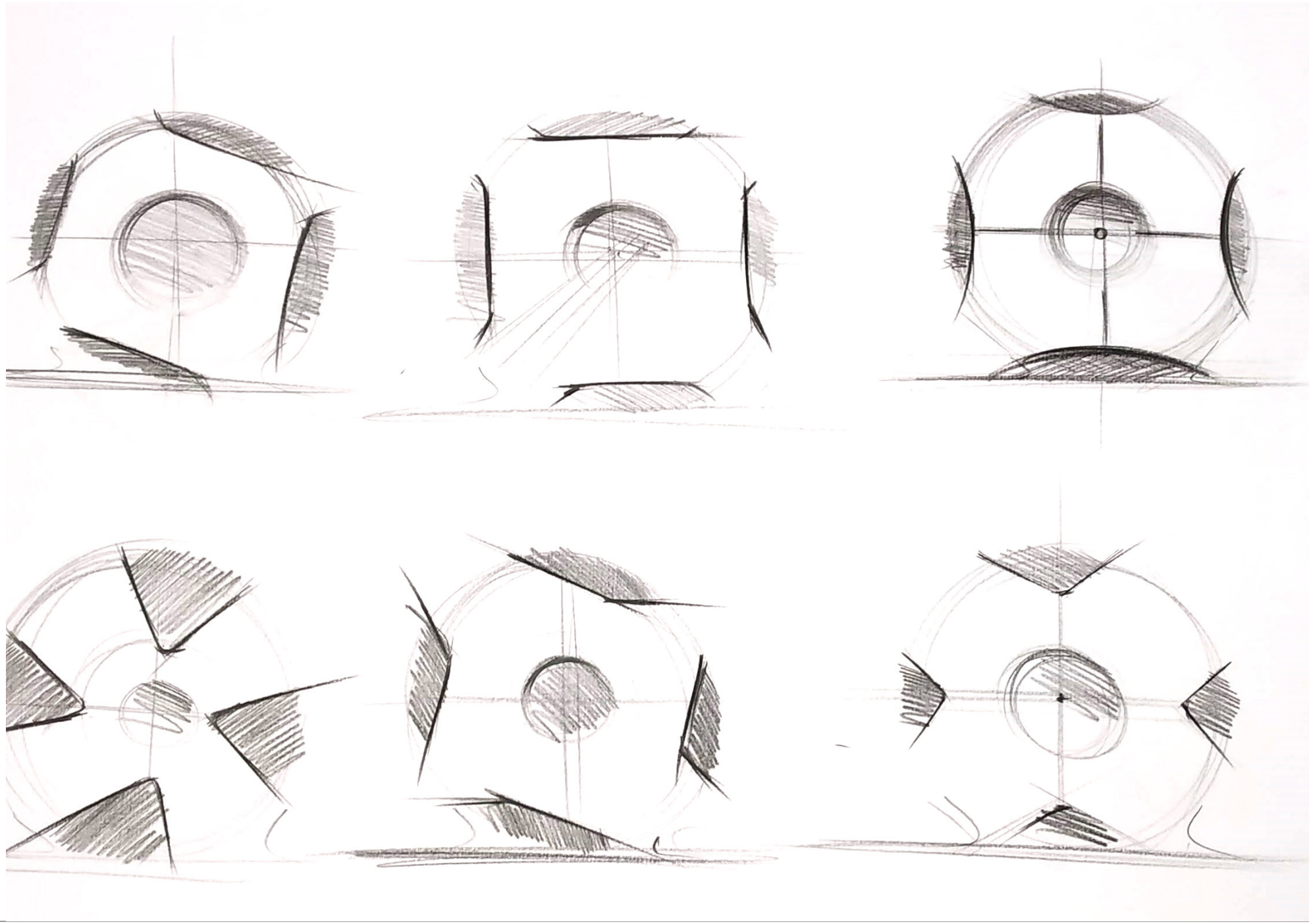


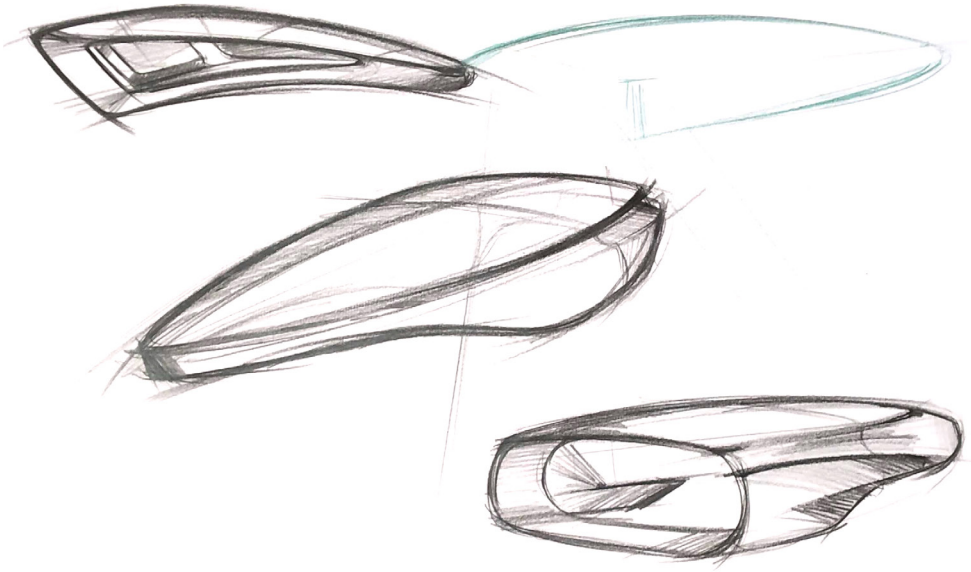


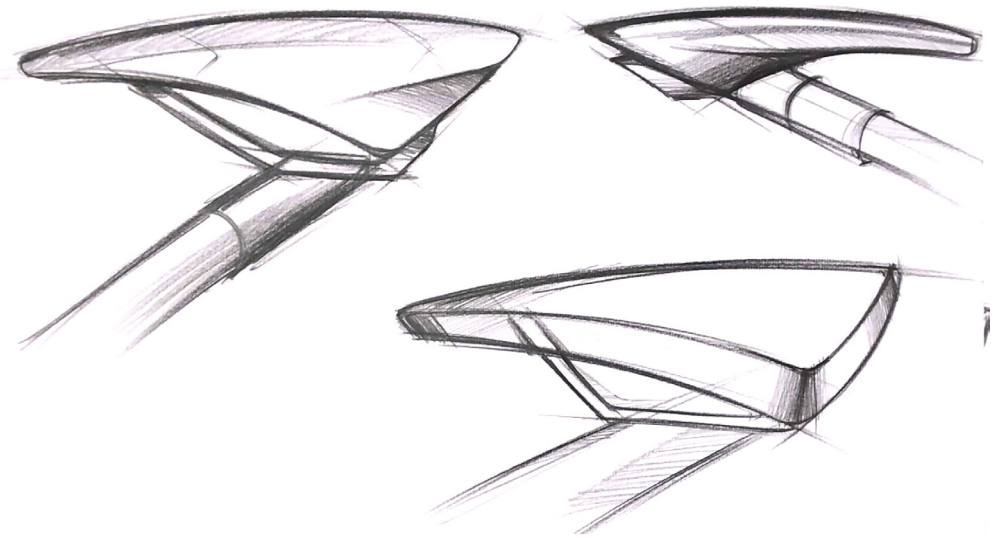


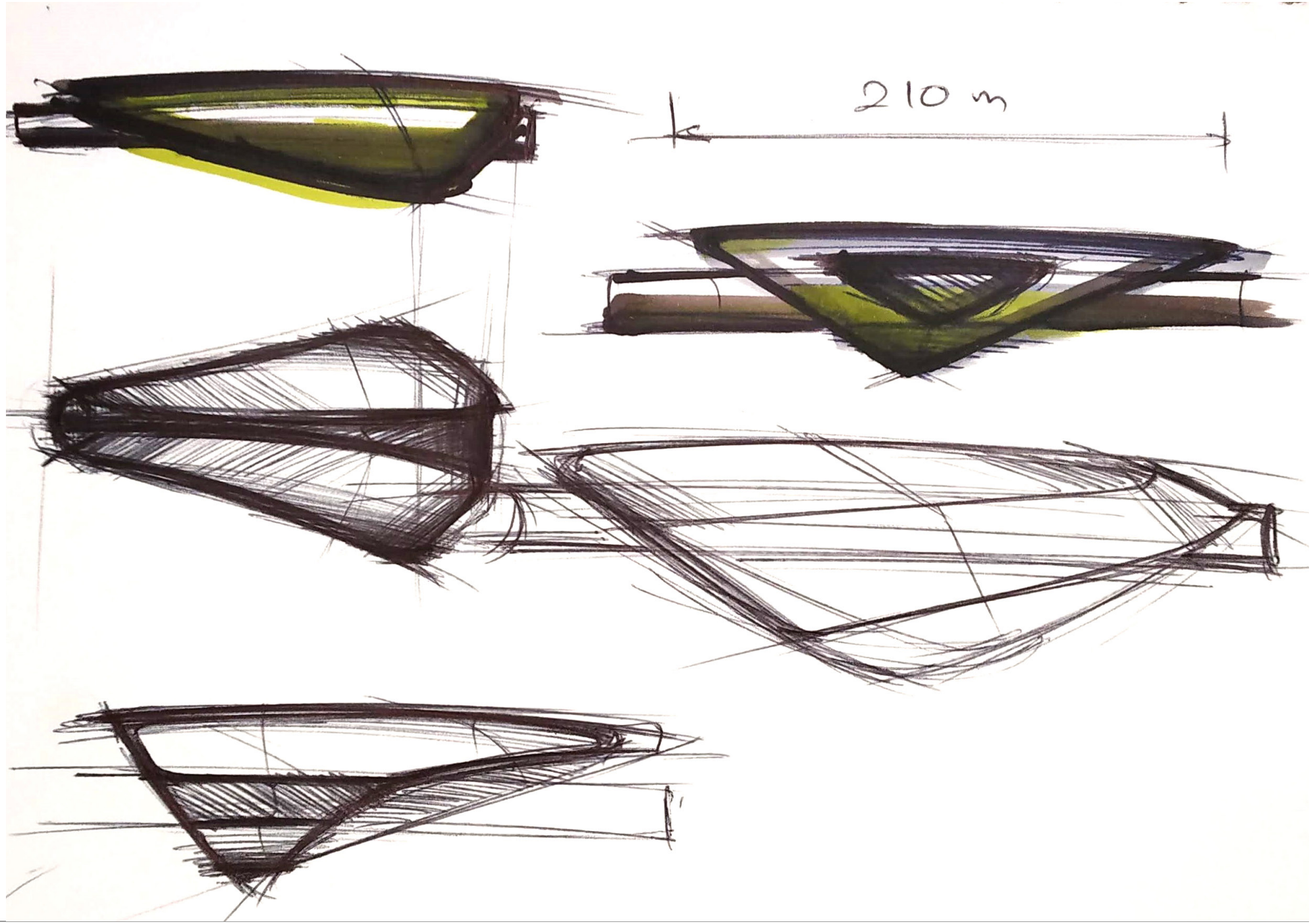


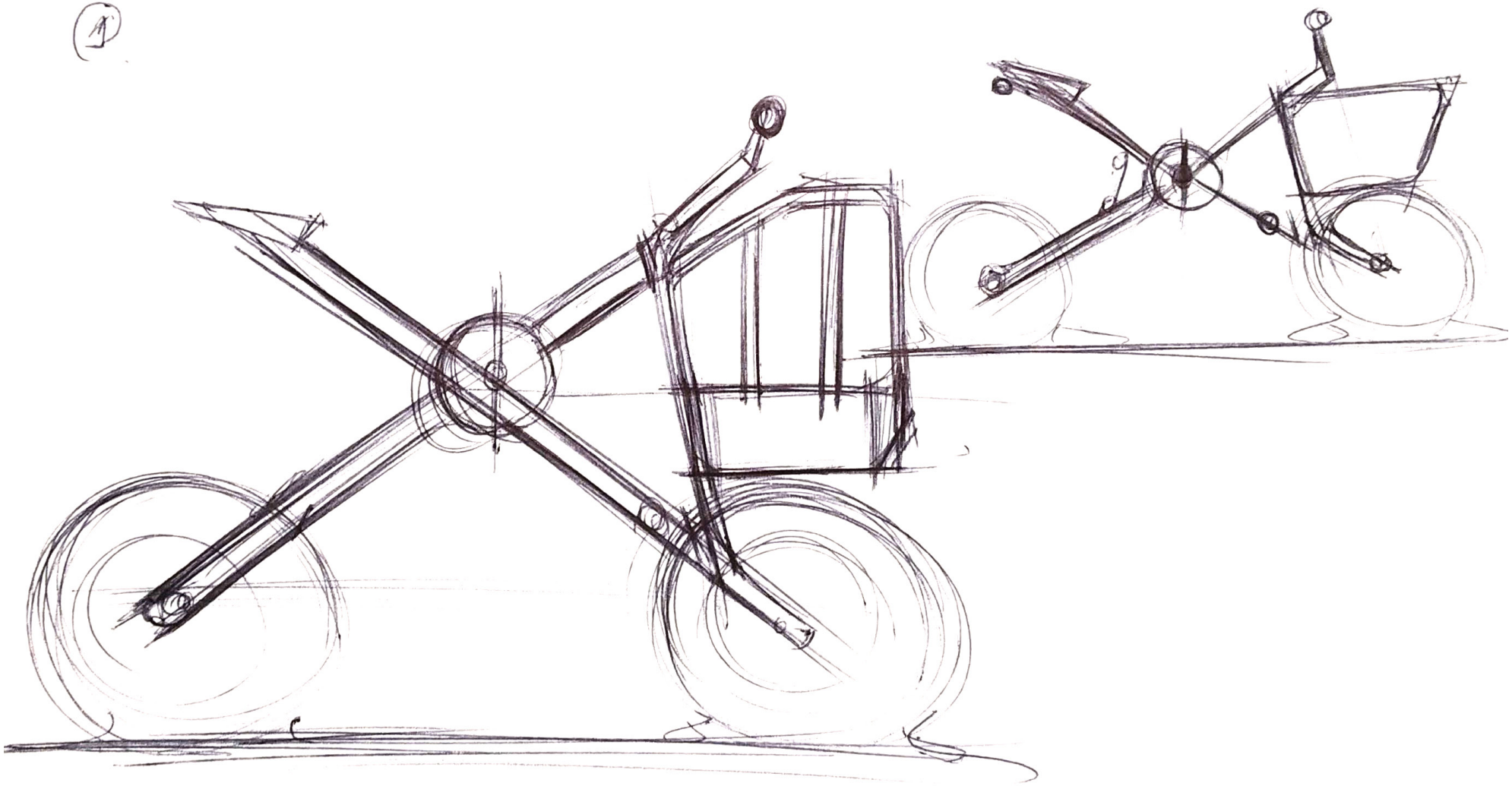


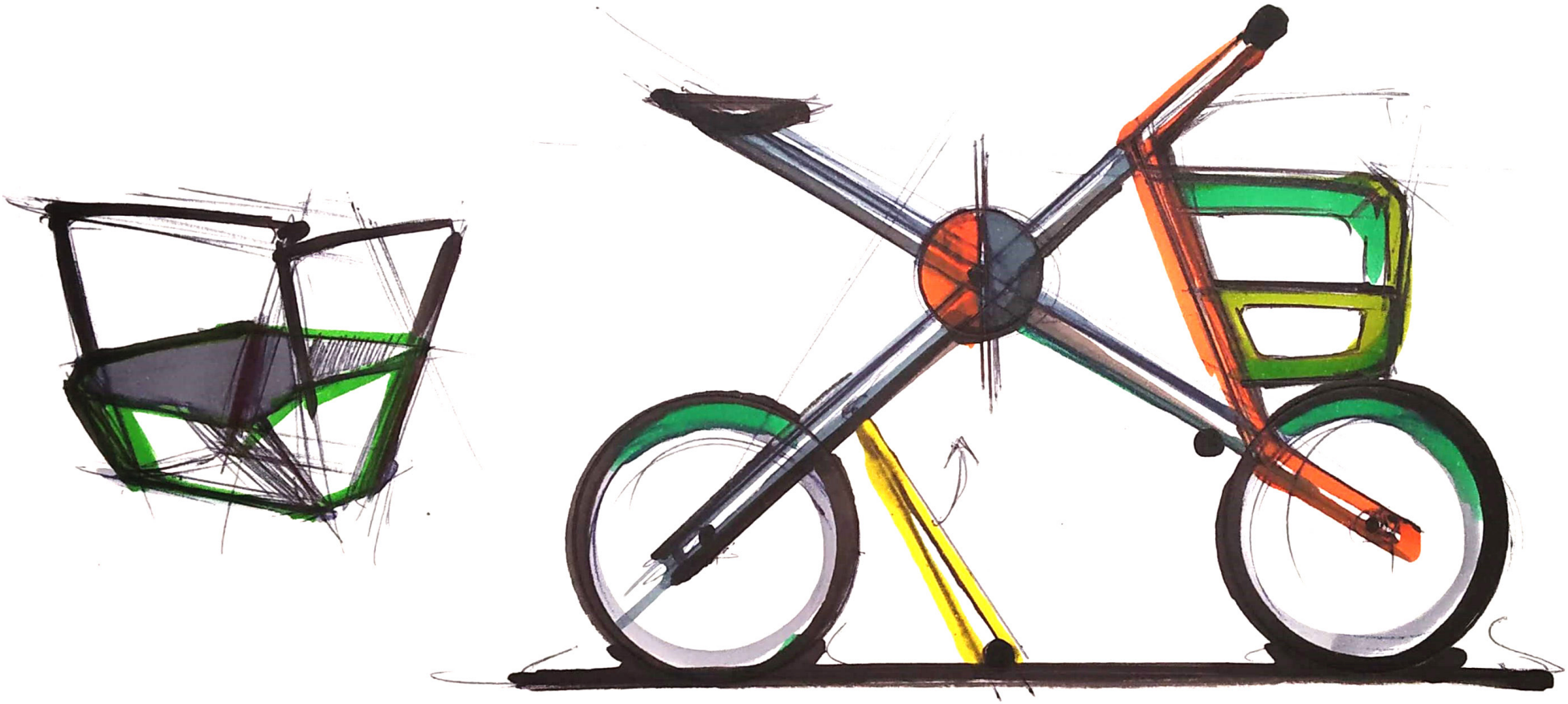







210 m





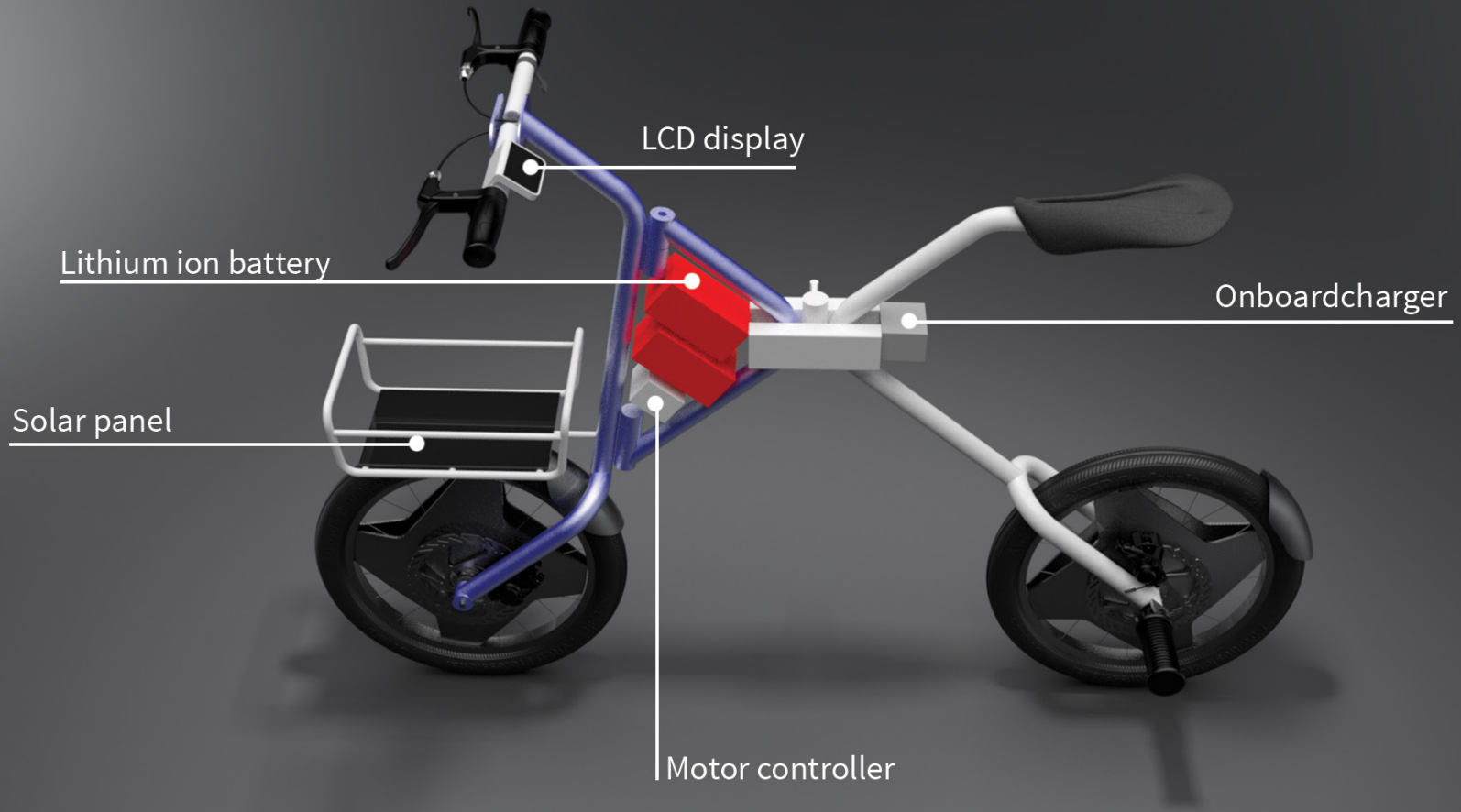

Foldable
Battery powered
LCD display
Disc brake
15 MPH
20kmph
Fast charging
BLDC motor
Keyless start

Final Render

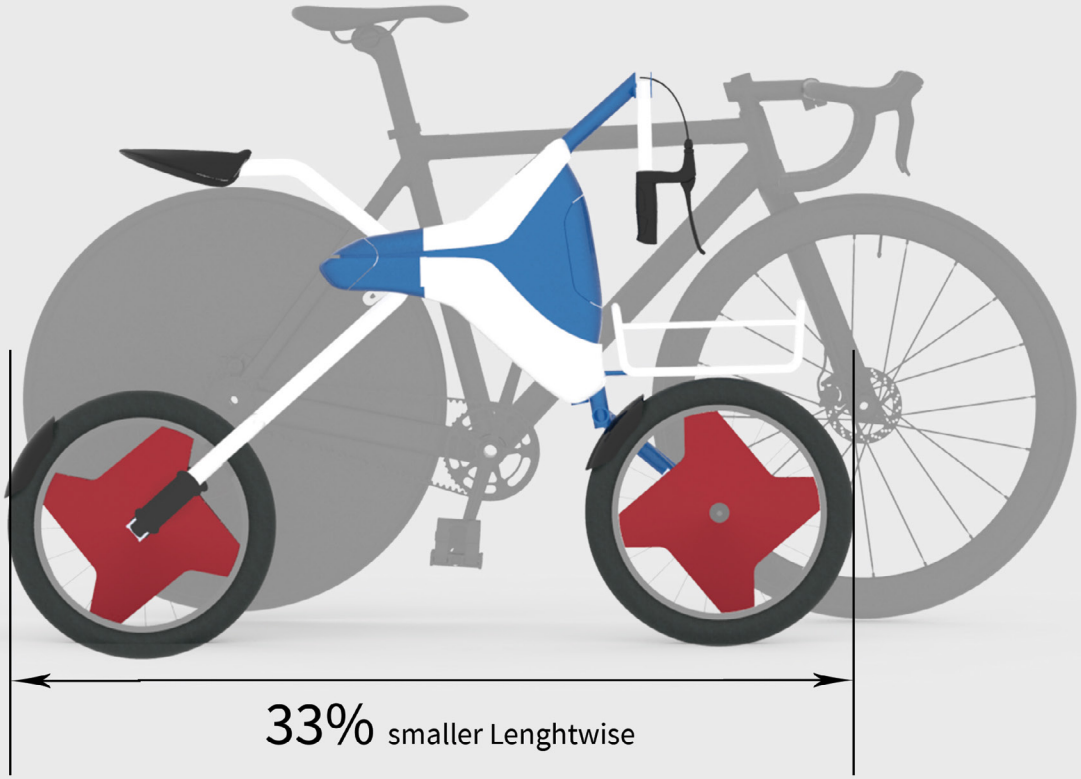
Final Render

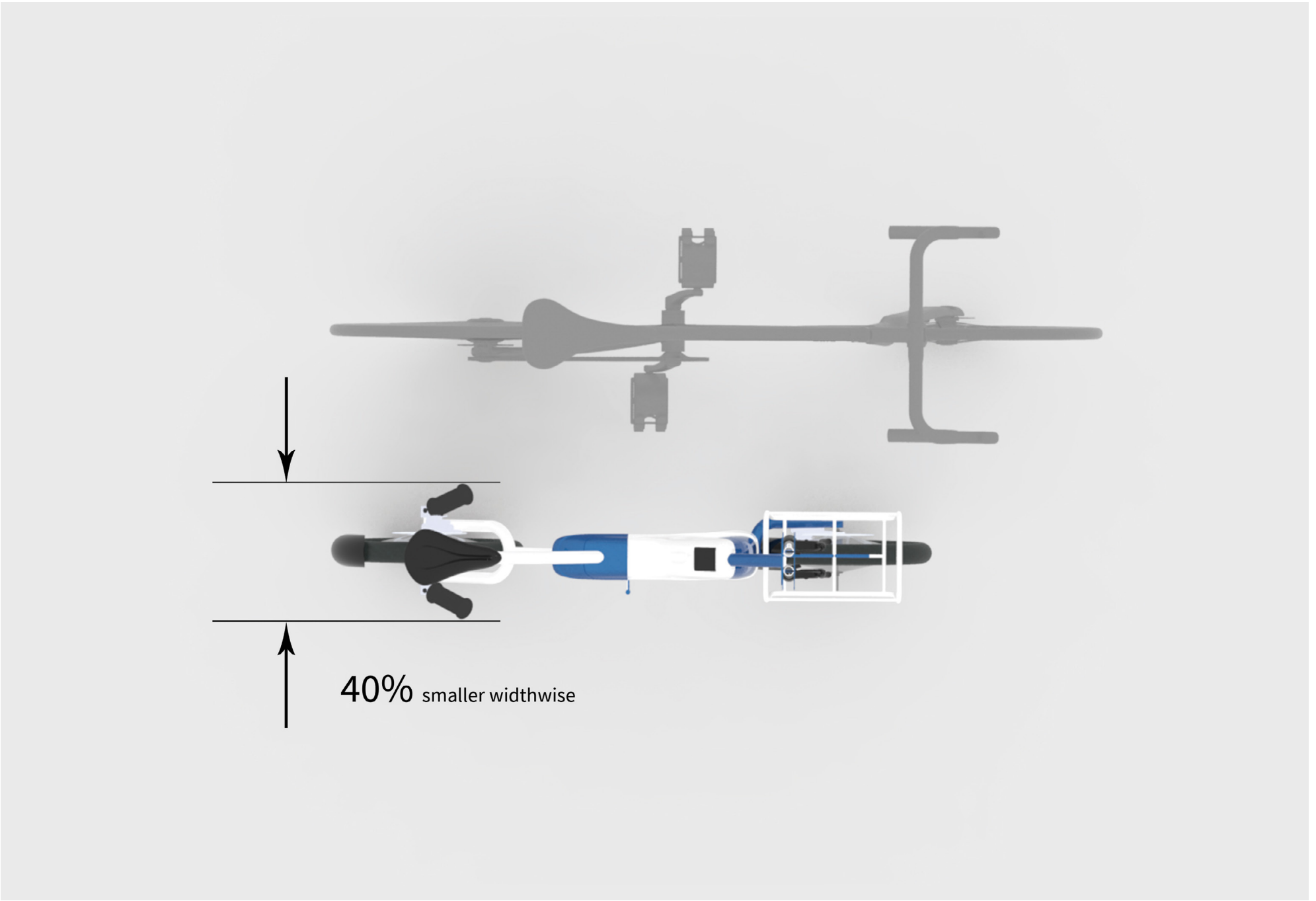

RFID scanner of Unlocking

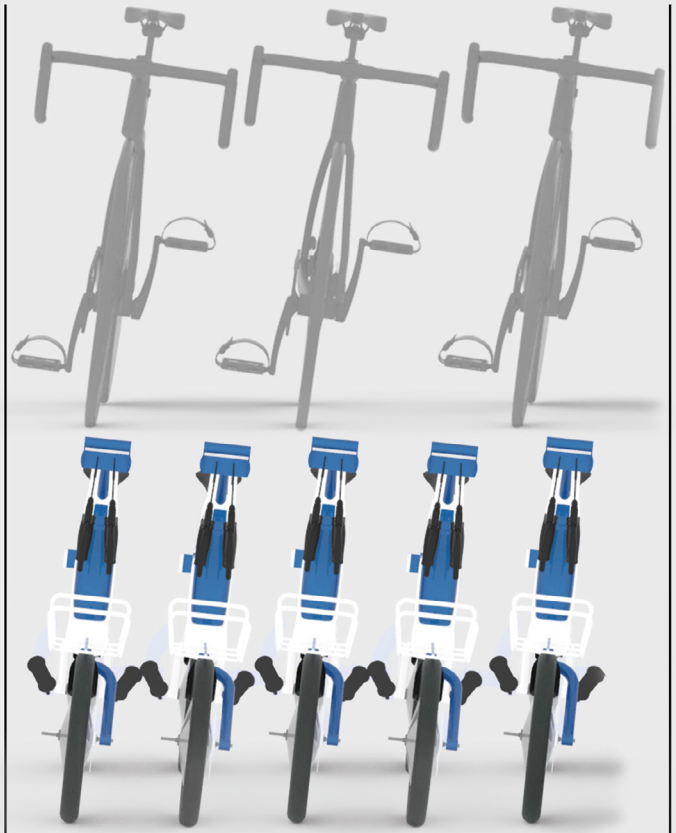
Packaging


LCD display
Lithium ion battery
Onboardcharger
Solar panel
Motor controller


E-BUDDY


33% smaller Lenghtwise

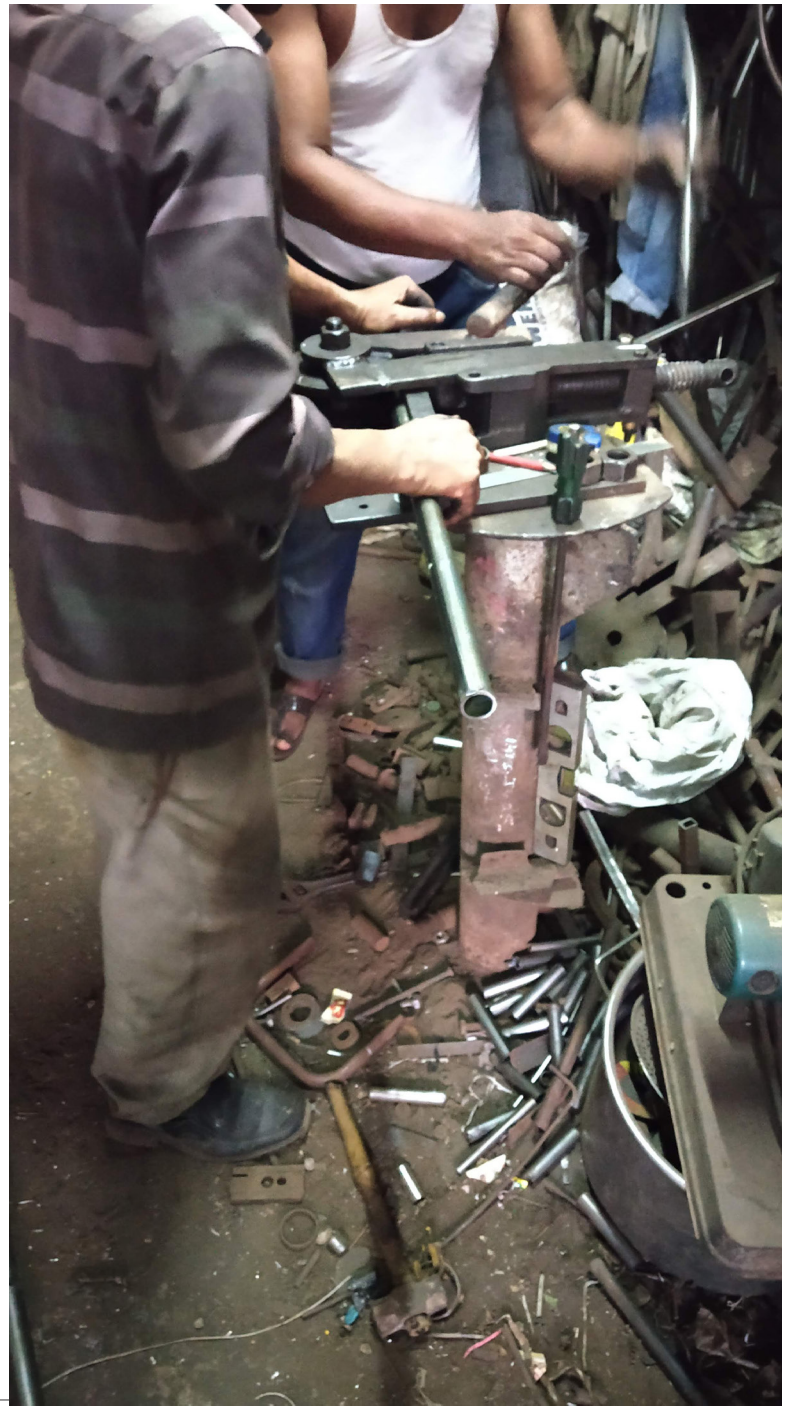

40% smaller widthwise



40% more efficent parking

8. Protoyping

Phase-1:
2mm 1inch Mild steel tube was bought.
Desired bent were made in tubes.



Phase-2:

Tubes were oriented properly and welded using TIG welding.

Phase-3:
Basket was manufactured and welding to body.

Phase-4:
Body panels were fitted to frame.

Phase-5:

Paint job was done.

9. Reference

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2. https://en.wikipedia.org/wiki/Bicycle
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10. Appendix

Sarvesh: I ride for 5 kms on average daily. Very few times in go out campus. I usually carry 40 litre of bag, laptop and set of books. I carry laptop bag and set of books. Because of uneven terrain effort is more on slopes. I don't like it sometime because i sweat at high slope. I sometimes choose alternative mode of mobility to avoid sweating and time travel. I have a problem when we leave bicycle for a month when we go out on vacation, it get rusty when i came back. Also there are less space to park when we leave for vacation. I have chose the economic bicycle because i don't want to take it after graduation.


Daily average distance travel: 5kms.


Maximum speed: 10kmph


Vehicle cost: 8000 INR


Bagpack: 40litres

Nandu: I travel for 10kms a day. I like riding bicycle. I carry backpack all the time. Raining season is the hectic season where riding becomes messy. Rust is the issue if i keep my bicycle outside for long time. For me i like to have personal mobility, i don't depend of shared mobility. Budget is not a contain if the product is worth buying it. I would love to drive hybrid system because its healthy. I am not sure about stiage thing but yes a detachable one will work for me. I am more into aesthetic of a bicycle, i don't want to compromise it. Parking is the issue for me,i feel difficulty in finding my bicycle and parking it. I don't like bike accessories.


Daily average distance travel: 10kms.


Maximum speed: 10kmph


Vehicle cost: 11000 INR


Bagpack: 20litres

Enlin: I drive bicycle because of rule in college plus it is eco friendly mode of transportation. Drive bicycle all time. I travel bicycle on an average 7kms. Carry rain coat during rains, water bottle, badminton racket, tennis racket and balls. Sometimes carrying racket on backpack hits my head when i sit up straight. Sometimes carrying sweater and everything makes backpack heavy, when i doing internship. Problems in finding cycle when i park outside. Inside human powered vehicle is ok but i need powered mobility to go out. Suitable position of bag for me is middle and rear. Sometimes i carry more stuffs to lab when i do project.

Daily average distance travel: 7kms.

Maximum speed: 10kmph

Vehicle cost: 14000 INR

Bagpack: 32litres

Subham: I ride a non geared bicycle, slope inside campus kills me. I don’t have storage space ,sometimes I have to carry stuff in hand and handle. Mudguard should be proper. Keeping outside for long in rainy season made my cycle rusty, i would prefer to take my bicycle up in my room. Security is another reason for me, to not buy expensive bicycle. I can spend not more than 10k for a bicycle.

Daily average distance travel: 2kms.

Maximum speed: 10kmph

Vehicle cost: 10000 INR

Bagpack: 32litres

Manish: I have a non geared cycle. Once i forgot to lock my bicycle before leaving for vacation, someone used it and damaged it. I have serious issues with security of my bicycle. Bicycle saves time and effort but creates problem in slope. I don't require storage in but sometimes i need it. I can't spend not more than 10k for a bicycle.

Daily average distance travel: 6kms.

Maximum speed: 10kmph

Vehicle cost: 10000 INR

Bagpack: 32litres

Sukant: I have a non geared bicycle but i don't ride it, it is boring. I would like to have a hybrid powertrain. I carry 5kgs of load everyday in backpack. Sometimes I put extra luggage in handlebar. I have travelled 20kms outside the campus. Parking is issue because i forget sometimes where i have parked it. It will be easy if i keep it my room. To buy any bicycle 10-15k will be my budget.

Daily average distance travel: 10kms.

Maximum speed: 10kmph

Vehicle cost: 10000 INR

Bagpack: 32litres

Ishu: I have a geared bicycle, i don't drive regularly because of laziness. I have a permanent parking space so i don't forget where i have kept. Slope in front of convocation hall is problem from sometimes. I am scared of accidents happening at that junction. Gears can be made more efficient. I carry a laptop bag but sometimes i have to carry a book but i don't have a bag then i carry it in hand. For me budget is 10k maximum.

Daily average distance travel: 5kms.

Maximum speed: 10kmph

Vehicle cost: 10000 INR

Bagpack: 32litres

Sai: I have geared bicycle. I ride it everyday, it has become a lifeline for me . Average distance i travel daily is 5 kms. Bicycle is time saving and convenient. Slopes create problem to me especially when i have taken food and coming to attend class. I find it difficult when i place my cycle randomly and and i do it almost every time. If u buy a geared option i feel it requires frequent servicing. I can spent not more than 15k for any bicycle. I wish i could take it up to my room because of chaotic parking space and security reasons.

Daily average distance travel: 5kms.

Maximum speed: 10kmph

Vehicle cost: 15000 INR

Bagpack: 20litres

Shreya: I have ladies bicycle, it is a non geared version. I drive it regularly, I go to gym even outside the campus till hiranandani. I use different type of bags inside campus ,i find it difficult to ride when i have side bag or sling bag. Parking is tricky for me, i try to keep at same location every time still sometimes i forget parked bicycle. Bicycle is most convenient mode of transport inside the campus. I have always felt that parking system inside campus is inefficient. I don't mind large gradient but i don't like it every time,especially when i getting late or have to go to class urgently. My budget was 10k for new bicycle. I have felt that practically in all cycle is very much compromised. I am not fan of buying special accessories as they are not designed for specific bicycle model.


Daily average distance travel: 5kms.


Maximum speed: 10kmph


Vehicle cost: 10000 INR


Bagpack: 30litres

Riddima: I have a geared version of city bicycle. I bought it in campus, i drive it almost everyday with campus. When i have to go out of the campus,i park my bicycle at main gate and take autorickshaw fmro there because i find security issues outside the campus. I use variety of bags,i always find difficult to carry all type bags. i get late to class i take autorickshaw to come to class. I felt that storage area i necessary part of it as out bicycle have very less functions to offer. I also had shoulder surgery so it pains if i carry side bag. When i bought a new cycle i had thought in mind that i will take it home anyways when i graduate from college, i wish to have a compact bicycle though i don't want to compromise aesthetic of it. My budget was 15k when i bought the bicycle.


Daily average distance travelled: 5kms.


Maximum speed: 10kmph


Vehicle cost: 15000INR


Bagpack: 32litres

Riddhi: I have a non geared bicycle. I don't use it frequently, i feel it as a liability as hotel is on walking distance and parking space is cluttered like hell. When i have to go out of the campus i take auto rickshaw, uber etc. I try to take bicycle when i have to go for swimming or gymkhana when i travel alone. I find difficulty when i park my bicycle, it crowded now a days in campus. I do find difficult with some attire,i prefer to wear skirt which i can't wear while i have to ride bicycle. I have always felt requirement of storage bucket but not basket i front,it make handling heavy. My foot slips from paddle, i feel look should be more efficient and easy to operate.


Daily average distance travelled: 8kms.


Maximum speed: 10kmph


Vehicle cost: 7000 INR


Bagpack: 20litres

Nikita: I have non geared ladies bicycle, same bicycle i have it my home. I use it regularly to go to class. I put my bag in the front basket, it makes handlebar heavy but i don't want to wear on my back, i feel scared and i has become my habit. I do find difficulty on slope,gradient is very high. Parking the cycle is pain, it takes more to park then to travel from hostel to lecture hall. Security is another issue for me my bicycle have been stolen twice, fortunately it was kept inside the campus. I have always felt campus is big and we need a convenient mode of transportation. I have searched for the compact bicycle in market but i didn't get good and affordable option. Riding a bicycle is healthy option but i feel electric assist will help me alot. My budget was 12k to buy a new bicycle.


Daily average distance travelled: 5kms.


Maximum speed: 10kmph


Vehicle cost: 12000 INR


Bagpack: 20litres

Priyanka: I have geared mountain bicycle, i use it regularly to commute within campus even i have travelled outside the campus till juhu. I like bicycle as it is the most convenient mode of transportation and fun to drive at high speeds. I don't find it as practical mode of transport. I like the aesthetic look of mountain bicycle though we don't have bicycle culture but still i prefer to ride it alone. I usually wear jeans or pant, so i don't find difficulty regarding my attire, but i feel there is lack of storage unit in bicycle. I prefer a removable unit to attach detach when i need it. Parking is issue here in campus but cant help because there is no system to park it. My budget was 15k to buy a new bicycle.

Daily average distance travelled: 8kms.

Maximum speed: 10kmph

Vehicle cost:15000 INR

Bagpack: 20litres

Alka: I have non geared bicycle, i bought it when i joined college. I feel riding bicycle inside campus save lot of time, our campus are big. We are not allowed to have a motorized vehicle. I carry 40 liters backpack to class everyday. I always face issue while parking the bicycle, i consumes time to park and after parking it takes another 10 minutes to reach classroom. Bicycle have become a part of life and i personally have adjusted with it, buti do face problem with storage in bicycle. I would prefer to have option of electric mobility inside campus. My budget was 10k when i was searching for new bicycle.

Daily average distance travelled: 5kms.

Maximum speed: 10kmph

Vehicle cost: 10000 INR

Bagpack: 40litres

Deepika: I have non geared bicycle, i had plan to buy a good ladies bicycle but i could get so i ended up buying a simple inexpensive bicycle. It does create issues in slope,i have to make effort to ride it. It has become a permanent mode of transportation when i have to commute within campus but i don't take it out of the campus. I don't feel safe riding bicycle on roads. Parking i one big headache, i have to search for parking space everytime.

Daily average distance travelled: 10kms.

Maximum speed: 10kmph

Vehicle cost: 10000INR

Bagpack: 30litres

Shreyashi: I own a geared mountain bicycle. I use it more often inside campus as well as outside. But usually i walk, as every place is within 1km radius. It is liability for me but i do use it when i have to travel far inside campus. I always find lack of storage space i always carry sling back which slips when i ride bicycle. Slopes i one reason no to ride it more often. It get rust ever monsoon, i wish i could take it up to my room. I bought it for 12k and it was a new bicycle.

Daily average distance travelled: 2kms.

Maximum speed: 10kmph

Vehicle cost: 12000 INR

Bagpack: 32litres